# STUDENT STRESS EXPOSURE: A DAILY PATH PERSPECTIVE ON THE CONNECTIONS AMONG COGNITION, PLACE, AND THE SOCIO-ENVIRONMENT

A Dissertation

by

NIKKI ANNE WILLIAMS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2012

Major Subject: Geography

Student Stress Exposure: A Daily Path Perspective on the Connections among Cognition, Place, and the Socio-environment

# STUDENT STRESS EXPOSURE: A DAILY PATH PERSPECTIVE ON THE CONNECTIONS AMONG COGNITION, PLACE, AND THE SOCIO-ENVIRONMENT

A Dissertation

by

NIKKI ANNE WILLIAMS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Approved by:

| | |
|---|---|
| Co-Chairs of Committee, | Kai Elgethun |
| | Robert Bednarz |
| Committee Members, | Gregory Colwell |
| | Dianzhi Sui |
| Interim Head of Department, | Vatche P. Tchakerian |

August 2012

Major Subject: Geography

# ABSTRACT

Student Stress Exposure: A Daily Path Perspective on the Connections Among Cognition, Place, and the Socio-Environment. (August 2012)

Nikki Anne Williams, B.S., Texas State University-San Marcos;

M.S., Texas State University-San Marcos

Co-Chairs of Advisory Committee: Dr. Kai Elgethun
Dr. Robert Bednarz

Few health studies of psychological stress have examined individual socio-environmental stressors in the field at a daily path scale. An individual's conception of a stressful experience is inextricably linked to the process of cognitive appraisals, which are the meanings assigned to social situations and environments. Directly assessing individual stress exposures in the field as they are experienced requires mobile measures that are people-based, rather than using place- or activity-based proxies. The integration of time geography and psychology's theory of daily hassles/uplifts allow for the measurement of stressors from a geographic perspective. This study advances research on socio-environmental health exposures by (1) focusing on measuring a cognitive health exposure; (2) using mobile methods to acquire quantitative and qualitative field data; and (3) geo-referencing physiological responses to examine daily path patterns and commonalities in stress exposure. In this study, spatiotemporal paths linked with physiological measurement are combined with individual narratives on stress, place, and social situations to examine socio-environmental factors that influence stress exposures.

Mobile measurement tools include wristwatch Global Positioning System (GPS) units with synched heart rate monitors and digital audio recorders. Stress as operationalized in this study is a negative cognitive appraisal and related physiological reaction to internal dialogues and the surrounding socio-environment assessed through heart rate reactivity (HRR) and individual accounts. Measuring geographically referenced physiological responses and personal accounts is a novel field approach that captures the acute stressful episodes that are a part of daily life.

Results show that there is a difference between measuring stress through a static metric like the Student-Life Stress Inventory (SSI) and assessing stress with mobile self-report and monitored measures. The negative correlation between HRR and SSI total score appears to highlight the divide between fundamentally different measurement methods for stress exposures; active versus passive. Regardless of the relation with previous psychometrics the mobile measures used in this research produced a 75 percent concordance between the participants self-reported stress episodes and monitored heart rate (HR) logs. HRR episodes that build in intensity and then ebb toward the end are more common than those that have an abrupt beginning and ending point. The incorporation of ethnographic audio diaries and the participant survey provided insight about the influence of academic pressures on socio-environmental contexts relating to stress experiences.

# DEDICATION

To God, whose hand is in my every work and dream, and to my Aunt Baby, who was the first to encourage the possibility of a doctorate.

## ACKNOWLEDGMENTS

I would like to acknowledge some of the people who have been instrumental in the completion of the work for my doctorate degree. I am very grateful to my committee for their expertise, continuing support, and patience. If not for the fortuitous meeting that led to my introduction to Dr. Kai Elgethun at the 2005 AAG meeting, none of this would have transpired. I appreciate Dr. Elgethun's commitment to ensuring that his move from Texas A&M did not end the pursuit of my degree. Special thanks go to Dr. Robert Bednarz; I am fortunate that he was willing to hold down the fort here at A&M. He has kept me engaged and periodically reminded me that there is light at the end of the tunnel. Thank you, Dr. Brian Colwell, for challenging my overriding geographic perspective with an eye toward practicality and accuracy from a public health point of view. Dr. Daniel Sui, thank you for always pushing the edges of my thinking toward expanding theoretical directions.

I am grateful for the continued mentoring of Dr. Sherri Benn and Dr. Sarah W. Bednarz, both who have served as role models, wise advisors, and timely sources of encouragement. Another wonderful source of encouragement has been the geography sisterhood, Sandra Metoyer, Dr. Serena Aldrich, Dr. Injeong Jo, Gina Lane, Dr. Aya Yoshikawa, and several others who were always there to remind me that I am not on this journey alone.

Last but most assuredly not least, I would like to thank my mother for always being there for me, who is an endless fount of persistence and strength, possessing the

remarkable ability to put everything into perspective. And I would like to extend thanks to my father for his unflagging belief that I am capable of anything I put my mind to.

## NOMENCLATURE

A: Authoritative constraint

AAG: Association of American Geographers

ACHA: American College Health Association

AIDS: Acquired Immune Deficiency Syndrome

ALS: Amyotrophic Lateral Sclerosis

AM: Ante Meridiem

A&M: Texas University Agricultural and Mechanical University

B: Biological constraint

BP: Blood pressure

BPM: Beats per minute

BQH: B-Company Quiet Hour

BLDG: Building

C: Coupling constraint

CAMAC: Committee for the Awareness of Mexican-American Culture

CDC: Centers for Disease Control and Prevention

CS: Computing Services

CSA: Computing Services Annex

DNA: Deoxyribonucleic acids

DSM-IV: *Diagnostic and Statistical Manual of Mental Disorders*

EMA: Ecological momentary assessment

ESRI: Environmental Systems Research Institute

GIS: Geographic information systems

GMT: Greenwich Mean Time

GPA: Grade point average

GPS: Global positioning systems

HIV: Human Immunodeficiency Virus

HR: Heart rate

HRR: Heart rate reactivity

HRV: Heart rate variability

ID: Identification

IRB: Institutional Review Board

LATs: Location aware technologies

LBS: Location based services

MIN: Minute

O&M: Oceanography and Meteorology

OMG: Oh my God

PDA: Personal digital assistant

PM: Post Meridiem

PTSD: Post-Traumatic Stress Disorder

RCA: Radio Corporation of America

RFID: Radio Frequency Identification

SCC: Student Computing Center

SRRS: Social Re-Adjustment Rating Scale

SSI: Student-Life Stress Inventory

STIS: Space Time Information System

TAMU: Texas A&M University

3D: Three dimensional

USB: Universal Serial Bus

VR: Voice recorder

# TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

CHAPTER Page

# LIST OF FIGURES

FIGURE Page

FIGURE Page

FIGURE Page

FIGURE Page

FIGURE Page

FIGURE Page

# LIST OF TABLES

TABLE Page

# CHAPTER I

# INTRODUCTION

## Context of Research Problem

> Everyone experiences stress at some point in life. Scientists say that stress is a force or event that impairs normal stability, balance or functioning. For example, the stress of a strong wind might alter the balance of a suspension bridge so that the bridge swings from side to side. - Bressert 2006

Stress, a prevalent and popularized subject in the United States, frequently occurs in the lives of young adults pursuing degrees at colleges and universities (Gadzella et al. 2004; Carvalho and Gadzella 2006; Robotham 2008; American College Health Association 2009). Students live demanding, stressful lives, and stress levels are correlated to physical and mental health status, and by implication, quality of life (Cohen and Williamson 1991; Gadzella 1994; Phippen 1995; Stanley and Manthorpe 2001; Andrews and Wilding 2004). It is reported to be a primary concern among university health service providers and experts such as the American College Health Association (ACHA) across the country. Stress is implicated in three of the five big health issues on college campuses, which includes mental health problems, lack of sleep, and alcohol use (Wyckoff 2010).

---

This dissertation follows the style of *Annals of the Association of American Geographers*.

In addition to its health effects, according to Weiner, Russell, and Lerman (1979), stress affects college students' academic achievement, and the students tend to associate their accomplishments and failures with their internal cognition and external socio-environmental experiences (Carvalho and Gadzella 2006). Another major factor in the equation of students' success or failure is how they manage or cope with their stress levels. Stress management behaviors (coping strategies) can be adaptive and proactive (positive), or they can be maladaptive by responding in a damaging (negative) manner.

### *Defining Stress*

Stress, a disruption of homeostasis that may be triggered by alarming experiences either real or imaginary (Selye 1956), can be categorized into two types: (1) eustress, the lift associated with good and challenging experiences, and (2) distress, the tension experienced from negative or overwhelming events (DeLongis et al. 1982; Lazarus and Folkman 1984; Brown and Ralph 1999; Anderson and Pulich 2001; Gadzella et al. 2004). In this work the stress response is considered part of a process, which includes a stressor that is a physical or psychological stimulus, which is either consciously appraised or implicit (unconscious), and the body's reaction (stress) in an attempt to restore homeostasis (Lazarus and Folkman 1984; Waters and Sayette 2006).

Lazarus and Folkman (1984) assert that stressors derive from social contexts and require cognitive appraisal and meaning assignment before the stress response is engaged (Everly 2002; Ross, Niebling, and Heckert; 1999; Robotham 2008). Cognitive appraisal can occur as a conscious process or through implicit cognition, an unconscious

process. Implicit cognition has been studied by observing recovering drug users and others coping with addictions, when individual meaning is applied unconsciously, automatically triggering cravings or urges to engage in past behavior (Waters and Sayette 2006). Physiological responses to stressors prepare an individual to deal with the situation and can have adverse effects on health, such as immune suppression, heart arrhythmias, depressive episodes, insomnia, changes in metabolism and hormone levels, and increased blood pressure and heart rate (Everly 1989; Sapolsky 1994; Epel et al. 2004; Cohen, Janicki-Deverts, and Miller 2007; ACHA 2009). Consider the analogy of a rubber band; negative stress can stretch it beyond its resilience point causing it to snap, but positive stress is just the right amount of stretch needed to make the band useful (ACHA 2009). Several researchers believe the biggest influences on overall well-being are the hassles (distress) and uplifts (eustress) dealt with in the course of everyday living (DeLongis et al. 1982; Lazarus and Folkman 1984; Lazarus 1999).

As stated above, stress can be beneficial, and is called eustress, referring to the physiological changes in the body for the purpose of meeting the challenge of finishing a paper, winning a sports competition, or accomplishing some other task within reach (De Longis et al. 1982; Lazarus and Folkman 1984; ACHA 2009). With eustress, the tension is short term and alertness is brought about by physiological changes and subsides when the challenge is met. The body then returns to a relaxed state, allowing normal activities to resume (ACHA 2009). In contrast, stress becomes negative (distress) if the body cannot return to a relaxed state (DeLongis et al. 1982; Lazarus 1984; ACHA 2009). When the body does not readily return to a calm state the changes start to take a toll,

often leading to mental and physical exhaustion and illness. In summary, stress is beneficial in situations where it engages the fight-or-flight response for a specific purpose, but prolonged exposure to elevated states whether from psychological or physical sources adversely affects body systems (Selye 1956, 1978; Gadzella 1994).

### *Mobile Stress Identification*

The identification of specific socio-environmental sources of stress remains elusive. Robotham (2008) asserts, "…that thus far research into student stress has not offered a complete account and explanation of students' stress experiences" (Robotham 2008, 735). Identifying specific sources and offering more complete accounts of stress could increase the effectiveness of stress management interventions or guide university policy and program changes that focus on improving students' coping skills. Therefore, this study concentrates on pinpointing instances of psychological stress in individual students' lives in order to understand how their environment and the meanings they assign to situations and places relate to their experience of stress. From this point on, time-location, space-time, and spatiotemporal will be used interchangeably to mean the consideration of the variables of time period and position on the Earth. Understanding spatiotemporal influences on stress requires the use of a contextual theory that considers the interrelation of time and space. Time geography is a contextual approach, which focuses on the continuity and connection of time and space.

Hagerstrand's concept of time geography examines life paths (trajectories) and associated constraints (biological, coupling, and authoritative) that influence where and how a person's time is spent (Hagerstrand 1970).

Hagerstrand's (1970) term *choreographies* encompass a person's path through time and space as well as their environmental interactions that influence both person and path. Although this framework was first posited in the 1960s, researchers were unable to fully operationalize Hagerstrand's ideas until tracking, computing, and visualization technologies advanced in complexity (Pred 1977; Hedley, Drew, Arfin, and Lee 1999). Currently, researchers are using time geography theory and related methods to study human activity patterns in commuting, access to health care, access to opportunities, exposure assessment, and other areas associated with planning (Kwan and Lee 2004; Takahashi, Wiebe, and Rodriguez 2001; Elgethun, Fenske, Yost, and Palcisko 2003). This research strategy uses time geography in a manner that focuses on the process of cognitive stress appraisal, by determining the significance (meaning) of each stress exposure experienced by individuals during field monitoring, and simultaneously geo-referencing continuous heart rate.

### *Psychological Theory, Geographical Perspective*

In contrast to the geographical perspective, approaches from psychology deal mostly with summations of overall stress levels obtained through surveys that measure cumulative perceived stress or an inventory of factors in a person's life that carry high emotional strain values (Holmes and Rahe 1967; Kanner, Coyne, Schaefer, and Lazarus

1981; Lazarus 1984). This approach is beneficial for assessing general stress load and categories related to stress but is ineffective for distinguishing specific hassles and uplifts that are a part of an individual's everyday life (Lazarus and Folkman 1984; Gadzella 1994).

Robotham (2008) points out that most previous studies of student stress have used a quantitative approach utilizing self-report inventories to measure aspects of stress and health status. He also questions if "…concentrating on quantitative data in this way may lead to the rejection of subjective, anecdotal, and impressionistic information," which he posits would provide more insight into the sources of stress (Robotham 2008, 738). Gunderson (1974) previously stated that inventory type instruments primarily ask students to respond to a limited range of generic questions dealing with normally stressful situations and that these imposed parameters often fail to take into account the unique and variable experiences of individual students (Robotham 2008). Robotham (2008) points to the lack of qualitative studies on or qualitative components in research on student stress as a gap in the knowledge base and "calls for research that is capable of providing a more subjective explanation of student stress in universities…" (Robotham 2008, 738).

Static inventory approaches are unable to fully take into account the socio-environment and active cognitive processes that stressors are related to. A recent addition to psychology methodology has been studies that periodically prompt participants to report on their surrounds and/or feelings in conjunction with events using ecological momentary assessment (EMA) seek to gather in-situ information about

individual experiences (Shiffman and Stone 1998; Hufford et al. 2002; Shiffman, Stone, and Hufford 2008). However, scheduled prompting imposes a structure that does not necessarily correspond to participants' situations and interactions. The factors that contribute to an individual's stress experience are often complex, relating to personal interpretation, the surrounding socio-environment, personal ability, other people, and anticipated tasks or responsibilities. The relating factors are fluid, and capturing information close to the source in time, space, and cognition is important.

### *Place*

Our conception of place is inextricably linked to the process of cognitive appraisal, the individual meanings assigned to social situations and environments. The cognitive conception of place moves beyond simply referring to a location in space but rather signifies an area of space that we set parameters on and to some degree have preconceived meanings assigned to, and we have notions about what can and what cannot occur there (Sack 2003). Individual differences and diversity among people—race, age, sexuality, income, and so on—can be reflected in people's attitudes toward environments and social situations (Boys 1990; Rose 1997; Koskela and Pain 2000).

The experience of place is multifaceted and dynamic, contingent upon the local details of individual's circumstances and life courses, and is affected by spatial, temporal, and social contexts (Koskela and Pain 2000). The social component often provides the explanation (meaning) of the environment. For example, Koskela and Pain (2000) discuss place meaning in the metropolitan area of Olari, Helsinki, with a waitress

in her twenties; she explains that she avoids certain places but that it is not necessarily a conscious action (Koskela and Pain 2000). Minna, the waitress, reflects that it is often a subconscious action to avoid certain places, not because she would be afraid but because she has an unpleasant image of those places (Koskela and Pain 2000). Her explanation applies to the stress process; often a physiological reaction can stem from unconscious thoughts or individual interpretations of place.

**Research Significance**

Tying time-location information to cognitive, physiological, and ethnographic information is an emerging direction for geography and holds the possibility of revealing processes not previously distinguishable. For both public health and psychology, the implications are associated with expanding methodological approaches and tools for health assessment that relate directly to mobile measurement. A major issue when trying to quantify or explain daily path stressors is measurement resolution (Gadzella 1994; Lazarus 1999). Identifying psychological stressors in time and space has the potential to address the resolution issue by capturing the micro-scale interactions that affect stress level most. Discerning the spatiotemporal intersections where students are exposed to stressors can be used to uncover the underlying factors that attribute to their overall stress level, which can then be applied to coping strategies and stress management interventions. The ultimate goal is to test the feasibility of an innovative mobile method for discerning stress exposures and to start unraveling the cognitive and social-environmental landscapes that shape student stress. With the aid of location-based

technology, it is potentially feasible to pinpoint specific situations and/or places that are stressors.

Fundamentally, a geographic approach to stress research is needed because of the dynamic nature of people's lives. People are not static in time or space; as they move through their daily lives they encounter stressors that they respond to. It is important to be able to measure physiological responses during those intersections when stress arises. Measurement techniques focusing on recording psychological stress exposures differ from previous studies in public health and geography that examine activity-level relationships to environmental settings. One of the primary differences is that it has been demonstrated that mobile heart rate (HR) monitors accurately record HR elevations that are due to physical activity (Larsson and Henricksson-Larsen 2001), but relating HR elevations to psychological stress experiences in the field is a more complex undertaking.

This field approach to stress assessment captures the continuity of life's experience by going beyond mere snapshots in either time or space, moving toward a level of resolution that distinguishes psychological from physical stressors through a blending of technology-aided measures. Using a geographic perspective by collecting positional, physiological, and ethnographic space-time data to assess a cognitive health exposure is an innovation. Distinguishing the geographic variables that influence individual stressor patterns can inform programs and policies to alleviate stress, thus affecting associated health outcomes, both mental and physical.

## Research Hypotheses

A time geography approach such as the one used in this study is effective in measuring stress exposure phenomena and pinpointing stress events. The timing and location of stressors in an individual's daily path are related to the meanings (appraisals) attached to specific experiences and places. Therefore, these daily hassles and uplifts are the variables that most influence students' psychological stress level. The daily path-tracking techniques applied are capable of showing commonality and uniqueness in individuals' stressor responses. Audio diary data are capable of improving path-tracking resolution by adding personal insight to when, where, and under what circumstances participants experience stress that mobile physiokinetic methods (GPS and heart rate monitoring) alone miss.

### *Research Questions*

1. Is the time geography perspective effective at discerning field stress exposures?

   a). Can the model of Hagerstrandian constraints (capability, coupling, authority) explain factors associated with college student stress?

2. Are the instances of stress in an individual student's life associated with specific locations or a chronological sequence of locations?

   a). Do an individual's stressors have a temporal/locational pattern?

   b). How does an individual's perception of place influence his or her stress level?

3. Does a field tracking (GPS/HRR) method differ from participant audio diary accounts in terms of time/space placement of stressors?

**Research Methods**

Individual stress exposures were directly assessed in the field as they were experienced, through mobile measures that are people-based, rather than using place- or activity-based proxies (Miller 2007). The integration of time geography and psychology's theory of daily hassles/uplifts allows for the measurement of stressors from a geographic perspective. This study advances research on socio-environmental health exposures by (1) focusing on measuring a cognitive health exposure; (2) using mobile methods to acquire quantitative and qualitative field data; and (3) geo-referencing physiological responses to examine daily path patterns and commonalities in stress exposure. In this study, spatiotemporal paths linked with physiological measurement are combined with individual narratives on stress, place, and social situations to examine socio-environmental factors that influence stress exposures. Mobile measurement tools include wristwatch GPS units with synched heart rate monitors and digital audio recorders. Stress as operationalized in this study is a negative cognitive appraisal and related physiological reaction to internal dialogues and the surrounding socio-environment, which is assessed through calculated heart rate reactivity (HRR) and individual accounts. Measuring geographically referenced physiological responses and personal accounts is a novel field approach that captures the acute stressful episodes that are a part of daily life.

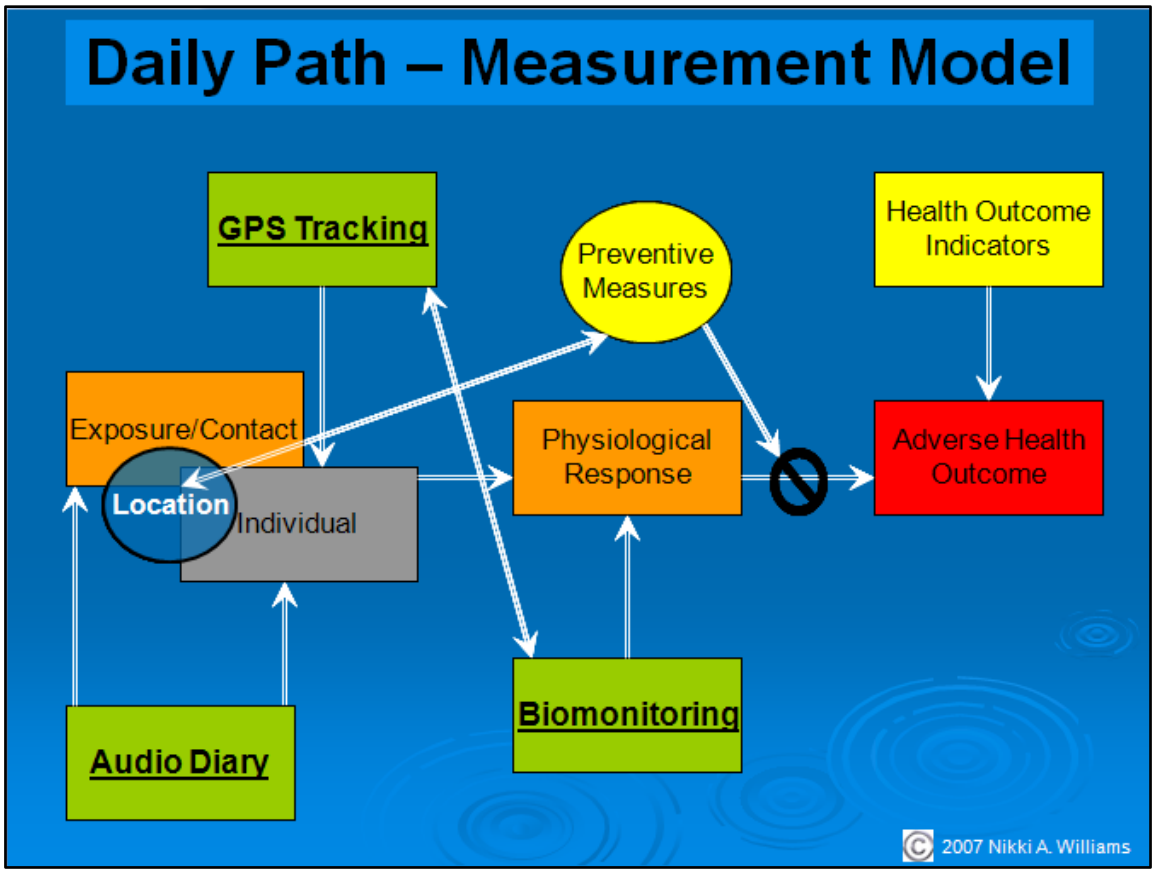



**Figure 1.** Daily path measurement model.

**Research Assumptions**

One assumption of this research is that structurationism, which seeks to resolve the opposition of "structure" and "agency" by erasing the misconception that material and social frameworks are the defining parameters and individuals can act only within their bounds (Johnston, Gregory, Pratt, and Watts 2005), is the most relevant perspective to use in unraveling the complexity of the stress experience. Hagerstrand's (1970) time geography falls under the umbrella of structurationist theory. The idea is that "structure" and "agency" are co-creators, integrated into one another, and therefore every moment,

movement, and action is a point of dynamic interaction between the two (Johnston, Gregory, Pratt, and Watts 2005). The components are not dualistic like good and evil; rather, they work in concert, simultaneously constraining and enabling each other (Johnston, Gregory, Pratt, and Watts 2005).

Another assumption is that a people-based theory, centered on understanding the movements of individuals in space-time, is better than using place-based proxies that catalog time spent in particular locations or participating in daily activities (Miller 2007). In 2004, Kwan and Lee were still lamenting the lack of studies using time geographic concepts due to the difficulty in obtaining high-resolution, individual-level data and appropriate spatial-analytic tools. However, technological advancement in the form of locationally aware technologies or (LATs) (GPS, radio-frequency identification [RFID], etc.) are shifting the data collection process from place-based measures (activity and travel diaries) to people-based measures.

This study also assumes that "states of health or disease are the expressions of the success or failure experienced by the organism in its efforts to respond adaptively to environmental challenges" (Dubos 1965, p. xvii; Meade and Earickson 2000). In other words, health is viewed as a system; it is dynamic, continually invested in coping with internal interpretations and the external socio-environment (Meade and Erickson 2000). Assuming that health is a system, integrated research is the realistic path toward understanding because a single way of knowing is insufficient for understanding the system's complexity (Miller et al. 2008). An interdisciplinary approach, combining geographic, psychological, and public health perspectives, spans academic divides to

provide a more cohesive view of health issues, because the process being studied is more complex than envisioned by any one discipline (Miller et al. 2008).

Additionally, there are assumptions made concerning the importance of the technology used and the degree to which human participants report occurrences truthfully that affect the overarching perspective and the results of the research. GPS with synched HR monitor technology is used (or assumed) as a "gold standard" for daily path measurement that includes physiological response. Other means for assessing daily path and physiology exist but considerations of accessibility, cost, obtrusiveness (size), equipment memory capabilities, ease of use, and reliability with continued novice use all played a part in the selection of equipment. Technology assumptions are related to participant assumptions, as data are at least partially dependent on the quality of the measurement equipment used. In the case of self-reported data, the "goodness of people" is relied upon. "Goodness of people" assumes that the research participants truthfully convey the facts and contexts of their experiences without aggrandizing, minimizing, biasing, omitting, or misrepresenting circumstances (LeCompte 2000).

**Research Limitations**

- Heart rate reactivity is the sole objective psychological stress indicator due to the lack of other ambulatory measures (blood pressure, temperature, skin conductance/galvanic skin response, cortisol level, etc.) synched to GPS units.
- Direct comparisons among participants cannot be made based on heart rate data.

- It is difficult to generalize data like self-report audio diaries that focus on individual experiences.
- Stimulants, including caffeine, drugs, medication, smoking, exercise, and excitement, are possible heart rate confounders.
- Gaps can occur in the GPS data because of unacquired or dropped satellite signals, user error, and equipment failure.
- Gaps can occur in HR data due to user error and equipment failure.
- The small sample size provides low statistical power (Urdan 2005).
- Bias (halo effect) can and often does occur in self-report measures (Goyne 2005).
- Recall bias and/or intentional misrepresentation of facts can occur in self-report measures (Berney and Blane 1997; Van Den Brink, Bandell-Hoekstra, and Abu-Saad 2001).

# CHAPTER II

# LITERATURE REVIEW

The daily path perspective on stress sits at the intersection of three disciplines: geography, psychology, and public health. Geography, in the form of daily path assessment encompassing movement in time and space; time-geo-referenced heart rate; and time stamp–referenced audio diaries integrate psychological and personal health data in a way that adds valuable information. The resurgence of geographic input in the health domain is a timely solution because in certain ways time and place are becoming simultaneously less and more important to the fragile complexity that constitutes individual human health. In moving time geography forward to address health concerns it is useful to draw on the expertise that has already been acquired in psychology and other health-related disciplines.

## The Problem: Stress Affects Health

### *Epigenetics*

According to Hunter et al. (2009), it was originally anticipated that the genome project would reveal everything contributing to neuropsychiatric disease, but that prediction has not proven true. Take, for example, a psychiatric disorder such as post-traumatic stress syndrome; genes simply cannot tell the whole story, because the development of the disorder requires a trauma since humans are not born depressed. In their study Hunter et al. (2009), found that a single acute stress episode of only thirty

minutes can cause rapid chemical changes in deoxyribonucleic acid (DNA) proteins in hippocampuses (rat) which is an area of the brain vulnerable to the effects of stress in humans and rodents. Research reveals that epigenetics is one mechanism by which a stressful experience can change the way that our genes are expressed; it shifts interest back to the socio-environment and how external events shape gene expression (Hunter et al. 2009). The real answers appear to be in the interaction of genes and the socio-environment mediated through individual cognitive appraisal. Epigenetic regulation of genes in the brain is recasting the way scientists think about stress, psychiatric disorders, and manifestations of ill health (Hunter et al. 2009). Measuring geographically referenced stress in a field setting is a novel approach that holds the potential to provide insight on important environmental pieces in the health puzzle.

### *Maladaptive Behaviors Linked to Stress in College Populations*

In a number of studies investigating negative health behaviors like problem drinking, smoking (and other drug use), and binge eating, researchers cite stress as a significant impetus for their expression among college student populations (Naquin and Gilbert 1996; Park, Armeli, and Tennen, 2000; Wolff, Crosby, Roberts, and Wittrock 2000; Park and Levenson 2002; Geisner, Larimer, and Neighbors, 2004). Often a cycle develops in which these maladaptive behaviors bring temporary relief but are followed by a need to reengage in the behavior, which creates its own stress (Zeidner and Saklofske 1996).

Problem drinking, a behavior used to alleviate stress, is not relegated to a specific age group, but Anglo-American men ages 18–24 have the highest rates of alcohol consumption as well as the largest percentage of problem drinkers (Ham and Hope 2003). Park and Levenson's (2002) investigation of this age demographic observed an increase of 13 percent, from 23 to 36 percent, between 1990 and 1994 in the number of students reporting drinking behavior when under stress. Men and women exhibit differences in their levels of alcohol consumption and the behavior's connection to stress. Men display a significantly stronger relationship between symptoms of psychological distress and alcohol problems when compared with women (Geisner, Larimer, and Neighbors 2004).

Problem behavior models associate risky behaviors such as alcohol and drug use to smoking (Wetter et al. 2004). Almost 30 percent of American university students have smoked within the past thirty days, 16.5 percent have smoked on twenty or more of those days, and among the 30 percent of college students who are current smokers, 34 percent smoke several cigarettes a day (Wetter et al. 2004). Smoking and emotional distress seem to have a reciprocal relationship, as evidence points to a trend of emotional distress prior to initial smoking behavior and the subsequent progression to regular smoking, increasing that distress (Naquin and Gilbert 1996; Wetter et al. 2004).

Stress-induced eating (binge eating), according to the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* (Wolff, Crosby, Roberts, and Wittrock 2000), is primarily reported by females and is defined as eating large quantities of food in a discrete period of time accompanied by a sense of lacking control over the eating

behavior (Wolff, Crosby, Roberts, and Wittrock 2000). Wolff, Crosby, Roberts, and Wittrock (2000) found that 25 percent of the female population admits to binge eating and 10 percent claim to binge at least once a week.

Using these coping behaviors is unproductive, and although they tend to produce an immediate reduction in tension or elevation of affect, in the long term these behaviors can produce adverse health and social outcomes. Problem drinking, nicotine use, and binge eating all carry health risks as well as other possible social or personal effects (e.g., accidents, academic problems, and family conflict). Eating disorders indicate serious emotional distress and can have grave implications for health, including heart problems and even death. Clearly, each of these maladaptive stress management behaviors has the potential to produce lasting and unfavorable results in students' lives. The link between stress and the expression of maladaptive behaviors is important to health outcomes and is a possible predictor of academic success among this demographic.

**The Theory: Psychology**

When Selye first coined the term *stress*, he used it "to describe the sum of nonspecific changes (within an organism) caused by function or damage or, more simply, the rate of wear and tear in the body" (Everly 2002). As a medical student Selye observed what he termed "the syndrome of just being sick," the body's response to events or situations that were taxing (Selye 1956; Everly 2002). A more recent stress definition put forth by Selye is the general response of the body when it is taxed (Selye 1974; Everly 2002).

It has been noted that the Selyean use of the term *stress* was not in keeping with the way the term was used in physics (Everly 2002). Because Selye's use of the word did not conform to the original definition already established in science it caused some confusion. Drawing from Hooke's Law (1676), stress is an external stimulus and strain is the organism's response to the stimulus (Everly 2002). However, in Selye's conception, stress is the response and a stressor is the stimulus that triggers the response.

To elaborate further, a stimulus is not actually a stressor until it elicits a cognitive and/or physiological response. As Lazarus and Folkman (1984) point out, stressors derived from social contexts require cognitive appraisal (assigning meaning) before the stress response is engaged (Everly 2002). Stress can also occur as an unconscious response (Waters and Sayette 2006). The stressor-stress response process that integrates stimulus, cognitive interpretation, and physiological response relates directly to the Lazarus and Folkman (1984) idea of hassles and uplifts. An event or situation is not automatically a hassle (stressor), depending on the individual's interpretation; it could be an uplift (positive) (Lazarus 1984; Lazarus and Folkman 1984). The stimuli that people encounter can be interpreted as distress, a negative situation that they might not have the tools to cope with, or eustress, a challenging but positive situation (Lazarus and Folkman 1984).

Stress literature is marked by the classic debate between the approach of Holmes and Rahe (1967) and Lazarus and Folkman (1984), each of whom constructed stress measurement indexes with different conceptions of the key variables to assess. Holmes and Rahe (1967) devised the social readjustment rating scale (SRRS) based on their idea

that major life events are the main cause of stress. They proposed that the stress values individuals assign to events such as marriage, death, pregnancy, divorce, illness, and moving could determine their level of stress or the magnitude of impact that such events would have on their lives. Approximately twenty years later, Lazarus and Folkman (1984) challenged the idea of major event stress on two levels. Their research focused on the concept of hassles and uplifts, which (1) contended that it is the small daily hassles/uplifts of living and not the major life events that most determine stress level, and (2) in addition, for hassles or major events, it is the cognitive process of appraisals and coping (how to deal) that determine what is stressful to an individual. Other research supports the assertion that daily hassles and uplifts are more significant predictors of stress level than landmark events (Kanner et al. 1981; DeLongis et al. 1982).

**The Proposed Solution: Geography**

The research undertaken contributes to the understanding of stress by bridging two different academic disciplines. The question of psychological stressors and their origins stems from the field of psychology. The theoretical framework and methodology for investigating the relationship between stress and an individual's spatiotemporal path come from geography. Time geography has found uses in the areas of planning (urban, transportation, and healthcare accessibility) but has not been readily applied to cognitive human exposure health studies, with the exception of current forays into the mobility of Alzheimer's disease and other associated cognitive illnesses (Hagerstrand 1970; Shoval et al. 2008).

### *Time Geography*

Schaerstrom (1999) is the geographer whose ideas regarding the interrelation of time, space, and health are an impetus for studies relating individual paths and particular health exposures. Granted, in his study of ALS, he studied life paths, a longer time scale than research focused on daily paths, but using the micro-scale focus on individual lives to understand exposure and relationships concerning health states is not dissimilar. His line of thinking "that it is insufficient to define disease occurrence in spatial terms, referring to patients' places of residence at the time of onset," is pivotal when considering health issues (Schaerstrom 1999, 235). The stress process is not isolated inside an individual's head; it happens within the context of time and space, simultaneously on a socio-environmental macro scale as well as an individual micro scale.

Time geography, a conceptual framework first posited by Hagerstrand in the 1970s, is an approach that seeks to reveal individual choreographies, daily paths (Hagerstrand 1970). It allows for the visualization of individual paths by mapping out chronological movement through space. To unravel individual trajectories through the landscape of life, research must focus on the space where an activity is taking place, while simultaneously considering the temporal scale (Schaerstrom 1996, 1999, 2005). The approach shows that exposure phenomenon, like many other phenomenon, reveal differing details at different resolution levels and when the dimension of space is viewed concurrently with an account of how it unfolds over time (Schaerstrom 1996, 1999, 2005).

This perspective can contribute to a more comprehensive understanding of health exposures and risks.

Hagerstrand noted that there are constraints upon people's lives. The three main constraints are contextual (biological), coupling, and authoritative.

- Contextual constraints are *biological* (B), such as our need to eat and sleep, or the extent of individual capabilities.
- *Coupling* (C) constraints are associated with tasks that require the assistance of other people such as on the job (teamwork or collaborative projects).
- *Authoritative* (A) constraints are situations that are dictated by an outside entity like the government, a supervisor, or a parent.

Time geography seems simple on the surface but research that attempts to account for individual life paths for specified periods of time is complex and ambitious.

When the concept was introduced in the 1970s, there was no readily accessible mobile way except for self-reported time/activity written diaries to account for a person's movement in time and space. Self-reported written diaries rely on individuals' ability to recall and/or to stop at specific times of day to record their location, time, and possibly activities being engaged in, which is problematic from a recall bias perspective as well as causing an intrusion upon participants (Berney and Blane 1997; Van Den Brink, Bandell-Hoekstra, and Abu-Saad 2001; Elgethun et al. 2007). Only in the late 1990s did adequate tracking technologies become available to assist in automated recording of trajectories, but early iterations of these technologies were bulky and had resolution limitations. Tools such as global positioning systems (GPS) have become readily

available and are now manufactured small enough to place in clothing or wear on the wrist to track a person's location throughout the day (Elgethun et al. 2003, 2004, and 2007). Tracking systems can also be set to record a location point at set time intervals. Therefore, not only does the unit pinpoint a location but it also attaches a time-stamp to verify or contradict personal accounts. Additionally, GPS technology has now started to integrate other measures. Two of the most readily available accessories are heart rate (HR) monitors and pedometers, measures which signify physical fitness level. HR is also a physiological indicator of stress exposures (Lazarus, Speisman, and Mordkoff 1963; Holmes and Roth 1985). Analysis of data collected from current tracking technology can reveal exposures or contact with agents that affect health status (Elgethun et al. 2003, 2004, and 2007). Although time geography has not been widely used to investigate health issues, it has great potential to show interactions where susceptibility and exposure intersect, putting people at risk (Jerrett and Finkelstein 2005).

### *Criticism of Time Geography*

Time geography has its proponents, the Lund School, Pred (1977), Miller (2005, 2007), Gren (2001), and others who acknowledge its utility, but it also has critics. Rose (1993) discusses the tendency of the time geography perspective to edit the expressive voice from individual paths, aspects that are joyous or disturbing, as well as the responsiveness inherent in connections with others (Johnston, Gregory, Pratt, and Watts 2005). She leveled this criticism even though in 1990 Dyck used the concept of time geography to study mothering, which is an innately nurturing and emotional role. Dyck

(1990) was able to show that routines in time and space helped to bring women in contact with each other in various locations and this helped to foster identity, self-esteem, and mothering (Johnston Gregory, Pratt, and Watts 2005). Kwan (1999) used time geography to assess women's access to urban opportunities. She departed from the use of traditional accessibility measures because of their perceived "inherent gender bias" (Kwan 1999). She instead employed individual measures of time-space movement to account for the behavioral and situational complexity related to accessibility that conventional methods lack (Kwan 1999). Time geography has been proven a viable perspective for discerning inherent gender bias, and the criticism of antifeminism can be leveled primarily if the researcher does not take the steps to integrate ethnographic or social data collection methods that give voice to gender or other cogent concerns.

Hagerstrand's theory has also been criticized for facilitating masculinism. Time geographic diagrams claim a certain power; they are seen as creating an illusion of mastery of an individual's path, thus rendering interactions with the socio-environment completely transparent, straightforward, and entirely fathomable (Johnston, Gregory, Pratt, and Watts 2005). Rose (1993) mocks this assertion of time geographic theory, taunting that there is nothing that cannot be known through this lens, no limit to its penetrative force (Johnston, Gregory, Pratt, and Watts 2005). Rose's criticism permeates deeper, as she uses the concept of "imaginary body" to illustrate that the Hagerstrandian approach of objective agent mapping is reductionist and akin to a body stripped of its sociocultural identification (race, ethnicity, gender, sexuality, etc.) (Johnston, Gregory, Pratt, and Watts 2005). Her point is well taken, because positions of power, mastery, and

the metaphor of penetration are masculine perspectives and modes of operation. Dyke (1990), Rose (1993), and others are simply arguing that the large, detailed amounts of data collected using time geographic research methodology do not negate the need for contextual narratives like cognitive process or sociocultural explanations to inform the abundance of information.

### *Time Geography–Related Methods and Health*

Methods of researching health issues using the time geography perspective are not new but they are shifting in measurement focus from activity-based measures, proxies that lack the capability to collect individual micro-scale data, to people-based measurement with the development of personal location–aware technologies (LATs) (Miller 2007). Time budgeting is one of the methods that is concerned with accounting for time spent on specific activities (Robinson and Bostrom 1994). Budgeting, unlike time geography, does not focus on interactions between a person and the environment, nor does it attempt to show the choreography of an individual's activities. The goal of time budgeting in a health context is to assign an activity (proxy for exact geographic location) to corresponding instances in time in order to reveal aggregated or generalized exposures that predict health effects. Unfortunately, the stated goal of the budgeting method and the usefulness of aggregated counts of time spent per activity are not compatible from a resolution standpoint. This approach arose in the gap between conception and effective implementation of time geography.

Time budgeting relies mainly on written time/activity diaries and related self-reporting methods (Robinson and Bostrom 1994; Klepeis 2001).

One direction of space-time analysis uses random or selected portions of a person's life path, measured through journaling, survey, and interview methods, to facilitate understanding of disease distributions, foster narratives on health landscapes, and discusses related health service/space accessibility (Kearns 1997; Takahashi, Wiebe, and Rodriguez 2001; Dyck and Dossa). Studies such as Takahashi, Wiebe, and Rodriguez (2001), dealing with Human Immunodeficiency (HIV), Acquired Immunodeficiency Syndrome (AIDS), and access to health care, are examples of time geographic studies that have not incorporated technologies such as GPS to validate written diary and survey reports. By documenting the in-depth daily routines of individuals with HIV and AIDS, Takahashi, Wiebe, and Rodriguez (2001) were able to distinguish how their individual activities and social networks influenced the availability of certain medical and associated services.

Tracking human activities in space-time has become more refined as technology has advanced. Initially human activity research had to rely on time budgets that used activity as a proxy for individual geographic location (Robinson and Bostrom 1994; Klepeis 2001). Keeping written activity diaries is tedious for participants and subject to recall bias (Berney and Blane 1997; Van Den Brink, Bandell-Hoekstra, and Abu-Saad 2001), especially when the report is made retrospectively, or marred by intentional omissions. Advancements in technology have spawned a number of tracking studies that use objective methods (such as LATs) that determine an individual's actual location rather

than using reported activities as a substitute (Elgethun 2004; Shoval and Isaacson 2006; Weaver and Gahegan 2007).

Many tracking studies credit time geography, a contextual approach to assessing human movement, as their theoretical underpinning (Hagerstrand 1970). Miller (2007) points out that time geography is a people-based theory and its full utility is only now reaching fruition (Hedley, Drew, Arfin, and Lee 1999; Miller 2007). In order to fill the gap between conceptual advances and the reality of tracking human movements some researchers have created their own geographic information systems that allow for improved visualization and analysis of space and time data simultaneously (AvRuskin et al. 2004; Meliker et al. 2005). For example, Meliker et al. (2005) developed Space Time Information System (STIS) to assist in visualization and analysis to reconstruct spatiotemporal data of bladder cancer patients to understand the connection between the disease and exposure to water containing arsenic. The system enables researchers to investigate toxic exposures by examining residential histories, representing space, over differing time scales (AvRuskin et al. 2004; Meliker et al. 2005).

### *Personal Exposure Assessment*

Personal exposure assessment, measuring toxic chemical or pollution exposure, is the main public health area benefiting from time geography analysis thus far (Elgethun, Fenske, Yost, and Palcisko 2003; Jerrett and Finkelstein 2005). Jerrett and Finkelstein (2005) reviewed several articles linking health outcomes with air pollution exposure using a conceptual framework in which the intersection of the geography of

susceptibility and the geography of exposure highlights the geography of risk. An example highlighted the need to examine exposure from both a space and time perspective by measuring air pollution levels in a particular region and then compared the activity space of a retiree and a commuter who lived within close proximity to each other (Jerrett and Finkelstein 2005). The results showed that even though the pollution level was elevated at the residence, the commuter was not exposed for the same amount of time because she travelled outside the high exposure area to work for extended periods each day and this factor contributed to differential risk for the retiree versus the commuter (Jerrett and Finkelstein 2005).

Elgethun, Fenske, Yost, and Palcisko (2003) used time geography to assess exposure to agricultural pesticides in children living in close proximity to crop fields. They used data from parent reporting, GPS tracking of children, and measurement of pesticide levels and then overlaid the children's paths with pesticide level gradients to identify exposure risk. Since the level of pesticide in the air and the child's location change throughout the day, exposure cannot be determined without relating both the temporal and geographic components of the data.

Human agency needs to be integrated into contextual models of health, which is in keeping with a call made by Miller (2007) to move beyond place-based perspectives and toward people-based methods to capture individual contexts. Focusing on people-based theoretical contributions is just as salient in health geography as it is in other research areas (Rainham, McDowell, Krewski, and Sawada 2010) such as transportation. Health research that incorporates place consists of multi-disciplinary inputs and it is not clear

what the best way is to operationalize concepts that seek to investigate contextual or place effects (Dear and Wolch 1987; Ellaway, Macintyre, and Kearns 2001; Pickett and Pearl 2001; Kawachi and Berkman 2003; Rainham, McDowell, Krewski, and Sawada 2010). Understanding how place does or might influence people's health not only requires information about the social structure in which they live (Curtis and Jones 1998; Graham 2000; Bottero and Prandy 2003; Bernard et al. 2007; Rainham et al. 2010), but also is enriched by tapping into individual cognitive interactions with the socio-environment. Autonomy varies among people as much from perceived constraints as tangible ones, which plays into the choices that a person makes in life, including those that affect health. In addition to human agency, Rainham et al. (2010) point out that often, based on the socio-environmental context or structure in a person's life, the idea of choice is actually illusory. "Yet it is often the interplay between people and place that ultimately influences health and health behaviors" (Rainham et al. 2010, 668).

### *Place Meaning*

It is clear that place contributes to health status, influencing activities and behaviors, through both direct and indirect means (Boyle and Willms 1999; Frolich, Corin, and Potvin 2001; Diez Roux 2002; Macintyre, Ellaway, and Cummins 2002; Popay et al. 2003; Rainham et al. 2010). For psychologists, perception is a part of or a function of cognition, and that role, in the form of cognitive appraisal, is how a person determines the meaning of a place (Golledge and Stimson 1997) or whether a situation is stressful to them or not. Geographers often use the term *perception* in a different way, basically for

how things are recalled by people, for example, risk, resources, or hazards perception (Golledge and Stimson 1997).

### *Mobile Methodologies*

When it comes to investigating a phenomena that takes place in the course of daily life it is natural to wonder what the difference is between static data, lab data, retrospective data, and data that are collected in the field as events unfold (Hein, Evans, and Jones 2008). New and subsequently smaller technologies are allowing researchers to be involved in participants' everyday processes in ways that not long ago were impossible. Unobtrusive technology, such as cell phones, miniature recorders (audio and video), GPS wristwatches (with synchronized physiological monitors and pedometers), and other tools give a view of an individual that is a mix of objective and subjective information.

Being in motion is intrinsically different from being stationary and needs to be considered when examining socio-environmental interactions (Hein, Evans, and Jones 2008). Social processes all take place somewhere and where can make a major difference (Hein, Evans, and Jones 2008). Similar to Hagerstrand's (1970) echoing question, "What about people in regional science?" some current geographies seek to focus on the level of the individual, the sensual experience of place, movement, emotions, and fostering the human level in the use of geospatial technologies (Miller 2005). Every sensory experience is processed via cognitive appraisal either implicit or

otherwise, giving meaning to the environment that surrounds us and guidance to our actions.

### *Audio Diaries*

Balogun, Huff, and Johnson (2003) suggest that one of the advantages of recording people during their everyday routines is that people are better able to describe and theorize in detail about their work, or lives when they are actually in that context. The advantage of context directly relates to collecting data regarding stressful experiences, as more detailed and insightful narratives are likely to be conveyed prospectively in the field. Furthermore, they point out that much of the research done on strategic management is concerned with the macro level and does not get at the details needed to understand strategizing practice (Balogun, Huff, and Johnson 2003). Similar to the daily path data provided by time geography trajectories, research in strategizing is shifting the focus toward individuals, their interactions, activities, and routine processes (Johnson and Bowman 1999). Mobile data collection enables the researcher to be close to the context of the participant (Balogun, Huff, and Johnson 2003).

Diary data collection methods are relatively unstructured; they are intended to elicit more personal information than standard questionnaires because relationships, events, and situations are reported firsthand. For example, Buchanan and Boddy (1992) used free-format audio diaries over two weeks that produced detailed accounts of experiences managing change. Daily diary data collection formats which have been somewhat neglected in social science research are finding utility for uncovering less than obvious

contributors to health outcomes (Milligan, Bingley, and Gatrell 2005). Diaries are finding use in real-time research when there is a need to track events through time, for example, capturing lifestyle choices, activity levels, and motivations of those suffering from chronic diseases like diabetes (Arsand, Varmedal, and Hartvigsen 2007).

Writing is time consuming and often lends itself to editing, which can lead to a sanitized or biased (Berney and Blane 1997; Van Den Brink, Bandell-Hoekstra, and Abu-Saad 2001; Goyne 2005) account of the phenomenon being measured (Balogun, Huff, and Johnson 2003). In light of technological advancements, including small and unobtrusive digital audio recorders, it is easier to dictate entries during, immediately before, or after an event occurs (Balogun, Huff, and Johnson 2003). Audio format entries are attributed with encouraging more openness, directness, and self-expression, as well as allowing more revealing observations than written accounts (Balogun, Huff, and Johnson 2003). Often as a follow-up to self-report methods such as diaries, interviews or focus groups are conducted to clarify the content of the diaries (Burgess 1984; Balogun 1998; Perlow 1997, 1999).

### *Heart Rate Monitoring*

Heart rate is a useful measure of physiological stress response. Although it is not the sole or most precise measure of the stress phenomena, it has an empirically tested track record. Heart rate is a simple measure that has been used extensively to gauge task involvement, anxiety, arousal, and mental effort reactions (Jorna 1991, 1992). Many of the studies using heart rate as a stress measure have taken place in clinical environments

where possible stress exposure is controlled and comes from a predetermined task. Kirschbaum, Pirke, and Hellhammer (1993) reviewed several experiments using an increase in heart rate above an established baseline to signify a stress exposure, and over two-thirds of the participants in each trial reacted with a heart rate increase above their baseline (Kirschbaum, Pirke, and Hellhammer 1993). The review done by Kirschbaum, Pirke, and Hellhammer (1993) also discusses the heart rate pattern that is most characteristic of a stressor, which shows the heart rates falling back to the baseline shortly after cessation of the stressor. Holmes and Roth (1985) recorded similar increases in heart rate to those in the research reviewed by Kirschbaum, Pirke, and Hellhammer (1993) when stress arousal was purposely manipulated. Additionally, it was found that participants with a high level of fitness experience a smaller pulse rate increase than those with lower fitness levels in response to stress but the high and low fit participants did not differ in their subjective stress reactions (Holmes and Roth 1985).

Vrijkotte, van Doornen, and de Geus' (2000) research is important because it establishes heart rate as an effective measure of stress exposure in ambulatory (walking around) settings (Pollack 1991). This step forward lends credence to moving stress research using heart rate as a measure out of clinical, controlled settings and into field settings (Pollack 1991). Increased HR, 4 beats per minute (bpm) on average, were found in the high-work stress participants associated with the few studies reporting on ambulatory HR and work stress (Vrijkotte, van Doornen, and de Geus 2000). The stress experienced at work was associated with a higher heart rate during as well as directly

after work and no difference in HR was found during sleep or on nonworking days (Vrijkotte, van Doornen, and de Geus 2000).

Development of GPS technologies with integrated heart rate monitoring has provided a new method for researchers to estimate the energy expenditure associated with children's movement (Duncan, Badland, and Schofield 2008). The HR data show that the children were relatively active during their lunch period but throughout most of their monitored time they engaged in slow or fixed-position physical activities (Duncan, Badland, and Schofield 2008). Results reveal that the combined approach of GPS/HR monitoring is a promising new method for investigating children's play-related energy expenditure (Duncan, Badland, and Schofield 2008), and that same integrated technology has the ability to discern other phenomena that effect physiological changes that include HR increase.

Other physiological measures of stress response are heart rate variability (HRV), skin conductance, cortisol levels, temperature, and blood pressure, some of which are considered more accurate measures of stress than heart rate (Fried 1984) but are currently more difficult to use in conjunction with GPS technology. Part of understanding human-environmental interactions includes being able to tie physiological responses to a place or situation, and none of the other measures are currently available synched to GPS units. Pinpointing locations can also allow for follow-up interviews or future research in which the researcher takes the participants back to an area where they felt stress to elicit a firsthand dialogue about their cognitive process.

# CHAPTER III

# RESEARCH METHODOLOGY

Previous work on college student stress has primarily used index questionnaires to assess stressors, stress level, and associated reactions, and to determine individual coping strategies. Although these methods yield useful information, they are removed from the situations in life that are related to student stress. Field studies or "naturalistic inquiry" endeavor to study real-world situations without the researcher designing the setting and by the use of non-manipulative, unobtrusive measurement tools (Golledge and Stimpson 1997). The following methodology seeks to bridge the gap between stressor context and stress assessment for the purpose of examining daily path commonalities of stress at a high resolution.

## Study Area

The study area for this research reflects the spaces in which the participating students live their daily lives. No parameters were placed on where participants could travel during data collection sessions. The primary geographical areas for data collection include the Texas A&M campus (Figure 2), College Station, Texas; and Bryan, Texas, but some participants travelled to other parts of Brazos County and wider ranges within the state of Texas or neighboring states during their monitoring sessions.

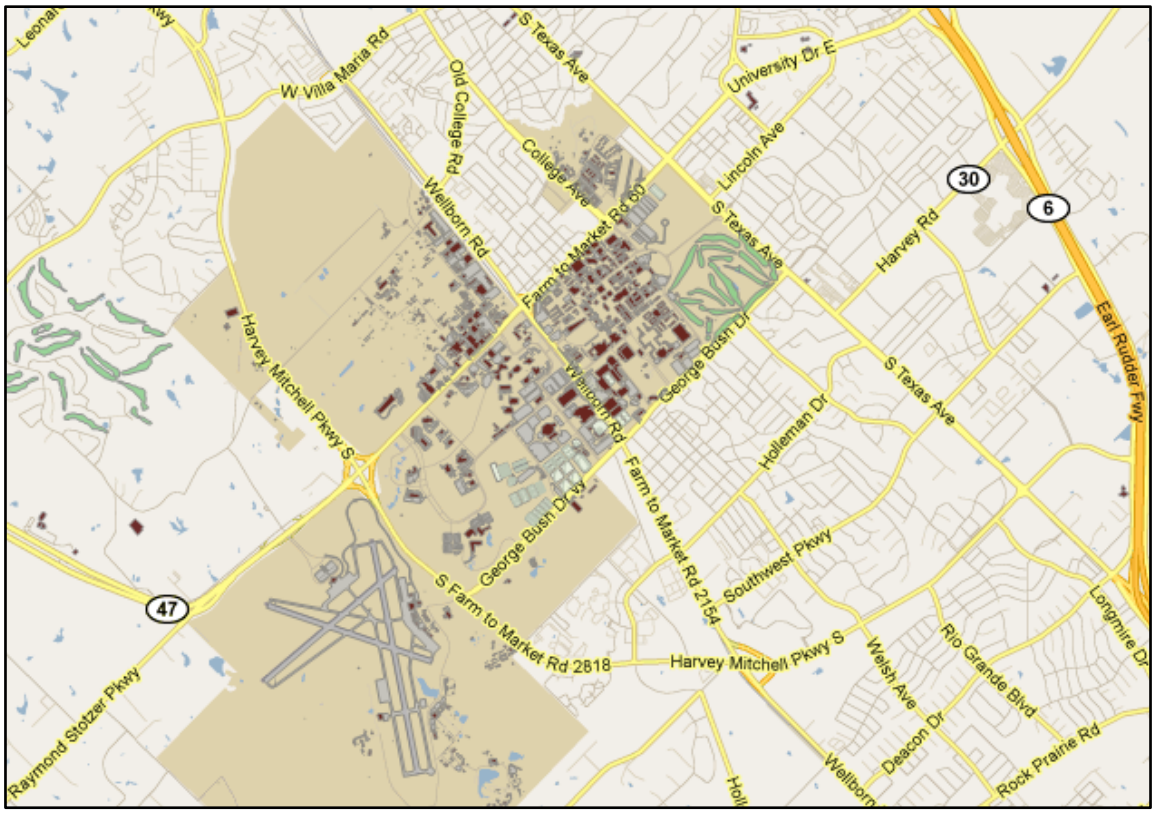



**Figure 2**. Study area: Texas A&M University College Station campus.

### *Sample Population*

The sample for this study consisted of twenty-three undergraduate college students from the Texas A&M University – College Station campus. Initially the sample population was based on the undergraduate student body; however, all of the students who took part in this research responded to the recruitment mass email (Appendix A) sent to the College of Geosciences (Geography, Geology/Geophysics, Oceanography, Atmospheric Science, the Water Program, and Environmental Programs) Listserv and recruitment presentations/information sheets (Appendix B) given in undergraduate kinesiology, world regional geography, and urban geography classes.

The criteria for inclusion in the study sample required students to live in College Station or Bryan, be enrolled in classes full time during the study period, be unmarried, be an undergraduate student, be available to attend one of the training sessions, and not have any preexisting health conditions that would confound the heart rate measurement. Questions on the participant survey (Appendix E) assessed the students' suitability to be included in the project by revealing physical and psychological conditions that may affect physiological measures and individual perceptions. Cohen, Kessler, and Gordon (1997) support a screening rationale, suggesting that potential participants dealing with depression or a diagnosed mental disorder not take part in studies examining cognitive appraisal (Cohen, Kessler, and Gordon 1997).

The students who met the research criteria were compensated with a Radio Corporation of America (RCA) voice recorder (VR) 5220 digital voice recorder (Appendix J) worth approximately $35 at the completion of the study. In addition, participating students recruited from geography courses were given modest extra credit points determined by their instructors. To be included in the study, participants were required to attend and complete a research training session that lasted approximately 2 hours in duration. During the training the participants were instructed on the proper use of the GPS/HR units (Garmin Forerunner 305 wristwatch) and digital voice recorders, the purpose of this study, and the data to be collected. Also during training, valuable data were collected in the form of the participant survey and the Student-Life Stress Inventory (SSI) (Appendix F). Finally, privacy/confidentiality issues were discussed and in accordance with Institutional Review Board (IRB) guidelines, participants were

reminded that they had the freedom to withdraw from the study at any time, without penalty or explanation.

Data collection took place over one month, from 11/11/09 to 12/9/09, which was after midterms and leading into finals of the Fall 2009 semester. The data collection consisted of each participant wearing a GPS/HR unit and keeping a self-report audio diary for 3 separate monitoring periods, the first lasting 5 hours, to familiarize themselves with using the equipment, and the subsequent 2 for 10 hour sessions. The average heart rate, later used in heart rate reactivity (HRR) analysis calculations, was derived by finding the mean (zero records excluded) of the combined sessions for each individual. HRR is a physiological stressor response of elevated heart rate above an individual's mean (Sharpley 1994, 2002). In order to assess change, baseline pulse rates were calculated to determine the magnitude of the increase in pulse rate during stress exposure episodes (Holmes and Roth 1985).

**Data Collection and Analysis**

Is the time geography perspective a feasible method for discerning daily path stress exposures? The aim of the data collected and the subsequent analysis was to answer the primary research questions concerning this geographic study of student stress. To answer this question, individual student choreographies were collected using the GPS/HR units. Each participant was monitored for three sessions and during each session kept an audio diary that described stress events that they encountered, the Hagerstrandian constraint(s) [A] authoritative, [B], biological, and [C] coupling that related to the reported situations,

and details of other factors that may have affected their heart rate. The combination of measurement techniques allowed for the collection of stress exposure data as well as personal accounts that included information regarding the socio-environmental context of experienced stressors. Measuring from both an objective and subjective perspective simultaneously provided space/time data by which stress exposure could be identified separately through the calculation of heart rate reactivity (HRR) and participant accounts.

### *GPS Tracking and Bio-Monitoring*

The Garmin Forerunner 305 wristwatch (Appendix I) unit with a synched heart rate monitor was used to record individual participant paths. The GPS unit has position resolution of 2 to 5 meters, records time/location every 5 seconds, and also measures speed, elevation, and distance traveled (Garmin). Heart rate data, in the form of beats per minute (bpm) were obtained using an unobtrusive skin contact sensor strip strapped around each student's chest that syncs, recording HR time and location, with the GPS. The heart rate sensor provides continuous monitoring, even when the GPS loses reception, but is unable to distinguish between increases in HR due to physical (exercise) and psychological stimuli. Discerning psychological stress exposure from HR data requires the additional information in the form of self-report diaries or other physiological measures.

Can the model of Hagerstrandian constraints (capability, coupling, authority) explain factors associated with college student stress? A question closely associated with the

feasibility of time geography for stress studies is whether the social constraint variables already proposed by Hagerstrand apply to stress situations in a student population. The measurement component used to address this is self-reported audio diaries. Digital voice recorders are compact and allow participants to quickly record relevant information or perceptions that they would not otherwise have time to capture in the field (Balogun, Huff, and Johnson 2003). Providing a convenient, mobile means of reflection helps to diminish recall bias and memory lapse issues (Balogun, Huff, and Johnson 2003).

### *Audio Diaries*

Self-report diaries are an essential component of the study methodology. The diary accounts were needed to determine the nature of psychological stressors and distinguish them from physical or other stressors recorded by the heart rate monitor. Additional uses for the self-reported data were to provide information for periods when the GPS signal failed (inside buildings, dropped signals, etc.) and for comparison with GPS/HR logs. Diary narratives speak to personal perceptions and can assist individuals in understanding the complex nature of the stressors in their lives. This approach is related to life charting (Figure 3) methods used to describe life course and events, which ultimately provide awareness and insight to psychiatric patients (Sunnqvist, Persson, Lenntorp, and Traskman-Bendz 2007).

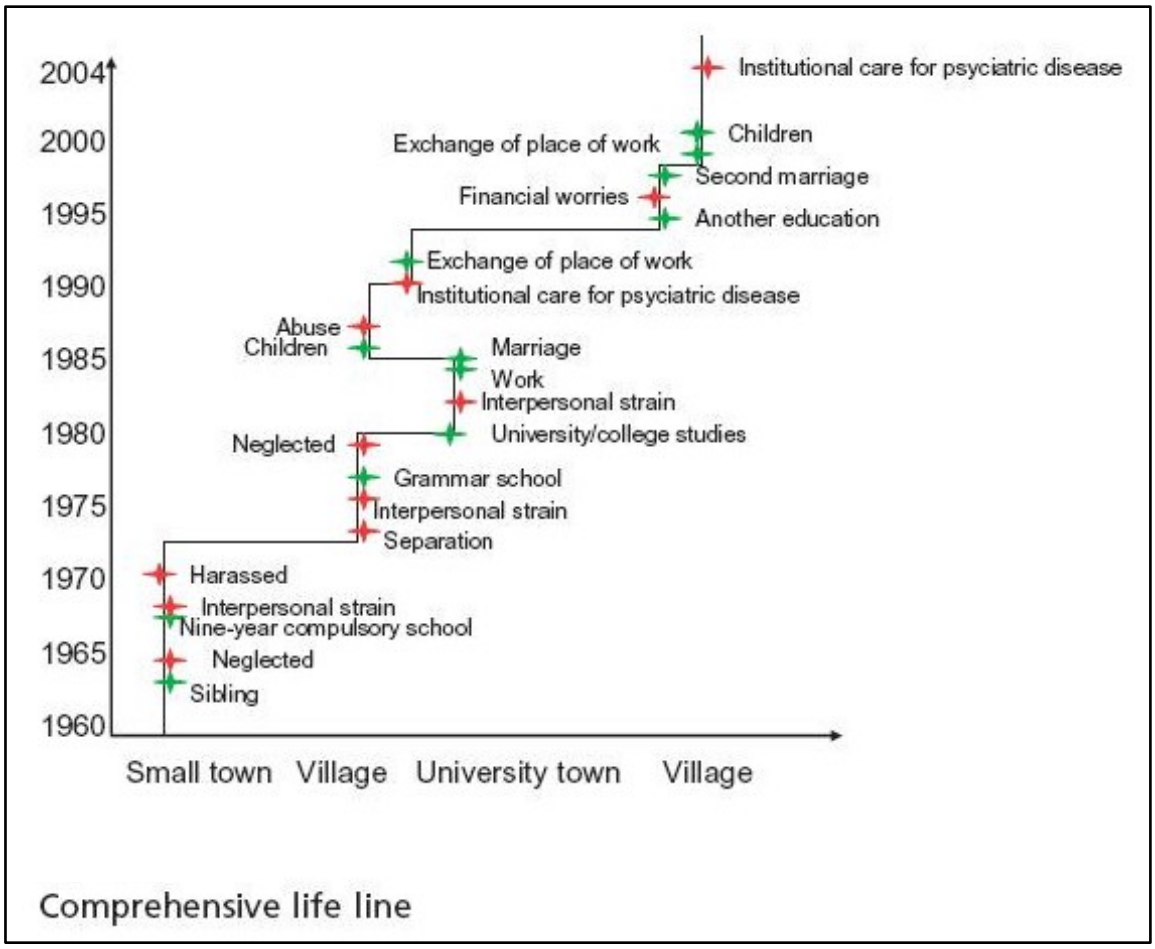



**Figure 3.** Life chart events: green = positive, red = negative (Sunnqvist, Persson, Lenntorp, and Traskman-Bendz 2007).

In order to understand how student stress relates to Hagerstrandian constraint types, the participants used a letter code to identify the constraint that was most closely associated with their current stress experience; A = authority, B = biological, and C = coupling. During training, the theory of time geography was briefly discussed and the constraints were explained in detail so participants would be able to assess the type of hindrance that best related to their stressful experiences.

### *Coding*

An important part of this study examined the events and responses taking place and how the participants made sense of their experiences. Coding, assigning meaning to descriptive data through labels is the main categorizing strategy used to analyze qualitative data (Bailey 1997; Maxwell 1998). The *a priori* codes for the analysis were derived from the Hagerstrandian constraints. Each participant's audio diary transcript was coded using the ATLAS.ti (Scientific Software Development) program. The straightforward codes, A, B, and C, as explained previously, were designated in sections of the transcripts when the participant's stress was attributed to one of the constraints (see Tables 8 - 27). Applying these labels facilitated intra and inter comparisons of participants' regarding what situations contributed to their experience of stress (Bailey 1997; Maxwell 1998).

## Stress in Time and Space

Are the instances of stress in an individual student's life associated with specific locations or a chronological sequence of locations? Determining stress exposure in the student population required more than one data collection strategy. Calculations using the GPS/HR unit data supplied the location and record of heart rate bpm to discern HRR, which is not a definitive measure of stress response; therefore, integrating participant accounts increased reliability by reporting confounding factors and physical activity. Additionally, place meaning and other relevant cognitive appraisals cannot be ascertained without participant input.

***Heart Rate Reactivity***

Heart rate reactivity (HRR) is the calculated measure used in this study to discern acute stressful events from the rest of the heart rate data collected. HRR is a measure supported by a number of research reports suggesting that it is either a direct cause or a correlate (risk factor) for cardiovascular disease, and more specifically the impetus of plaque formation on the surface of arteries that may progressively lead to blockage (Ross and Glomset 1976a, 1976b; Ross 1986; Sharpley 1998, 2002). The concept for measurement models for cardiovascular reactivity are straightforward; under normal circumstances there is a basal level of heart rate function from which heart rate is seen to increase while the organism is stressed and then it returns to the basal level (Sharpley 1994). "Heart rate reactivity is usually calculated by subtracting the heart rate at rest from the heart rate during a stressful event, although there are various ways of doing this" (Sharpley 1994, 2002, 57). Calculating HRR identifies stress exposures, one of the initial steps toward evaluating daily paths for relationships and patterns among time, location, and stress.

Do an individual's stressors have a spatiotemporal pattern? Analysis of daily path data from the GPS/HR units was performed with GeoTime software (Oculus). GeoTime provides insight to behavior in space and time by representing X, Y, T (latitude, longitude, and time (T) data entered into ArcGIS (ESRI) in a three-dimensional (3D) visualization (Kapler, Harper, and Wright 2005; Oculus 2009). Prior to being imported into GeoTime, the collected spatiotemporal data from the GPS/HR units was processed by standardizing the data (several thousand logged records) from each participant for

each session. Due to the GPS units' Greenwich Mean Time (GMT) setting, data processing required first time-correcting of all records. Then the data were brought into Excel (Microsoft) spreadsheets and separated into columns for date/time, latitude, longitude, bpm, and other pertinent categories. After each participant's data conformed to the standard, then the maximum, minimum, and mean (excluding zero values) HR were established for esch person's three monitored sessions. With the mean HR serving as the baseline, HRR episodes were distinguished by periods of deviation above the mean in the participant logs.

In ArcGIS (ESRI), from the standardized Excel worksheets, the standardized latitude/longitude data were converted into ArcMap events. The point data resulting from the latitude/longitude conversion into features represented the student's locations as they went about their daily activities. At this point individual data was separated by date to make separate maps for each monitoring session day. In the attribute (data) table for each day, query formulas were entered to select records that contained heart rates above the mean, and then for each session day a separate layer (shapefile) was created showing the spatial representation of HRR. Not all of the participants successfully logged spatiotemporal data for each of their monitoring sessions but maps were created from the ones with spatial data.

After separate maps were created for each participant in ArcMap, which included College Station city limits, county streets, Texas A&M (TAMU) property boundary, TAMU streets, and TAMU buildings shape files acquired from the Texas A&M University Map Library, they were imported into GeoTime for 3D visualization.

GeoTime events are represented in an X, Y, T coordinate space in which the X, Y planes show latitude and longitude and the vertical T axis represents time (Kapler, Harper, and Wright 2005; Oculus 2009). The 3D visualizations allow objects to be followed spatially and chronologically, which aids in understanding sequence, cause and effect, and patterns of behavior (Kapler, Harper, and Wright 2005; Oculus 2009). In GeoTime as opposed to ArcGIS, the HR data is displayed as a path in space and time, giving HRR episodes not only a geographical context but also a temporal relationship to events that occur before and after.

How does an individual's perception of place influence his or her stress level? As previously established, individual perceptions play a key role in the daily experience of stress. Collecting participant audio diaries is thus essential to understanding student stress exposure. One of the variables that the participants were asked to report in their diaries was place perception, especially as it directly pertains to feelings of stress. The task invited the students to reflect on how they related to the physical and social environment that surrounded them at any given time. The concept of place perception was discussed in depth during the training sessions because some participants had never heard the terminology before or had not considered the fact that locations connected to our daily path are more than just points on a map. Additionally, during the training sessions students responded to a question on the participant survey (Appendix E) pertaining to their specific relationships to place and stress on the Texas A&M campus.

**Self-Report Versus Mobile Monitoring**

Does a field tracking (GPS/HRR) method differ from participant audio diary accounts in terms of space/time placement of stressors? To assess the concordance between the GPS/HR data and the stressors reported in the participants' audio diaries, matrices were used that register each audio entry, whether the event is reported at the time of occurrence, the GPS logged location, the associated constraint if there is HRR episode, and the expert constraint assignment when it differs from that reported. The date/time stamp on the recorded file of each participant audio entry is important because it sometimes differs from what is reported, which is the case when the entry is being made retrospectively. If the entry is prospective it is marked (Yes) and if retrospective it is labeled (No) in the table. GPS concordance is handled numerically: (1) yes, this entry corresponds to logged location, (2) yes, this retrospective entry can be matched to logged location, (3) no, it does not correspond to logged location, (4) no location was given in this entry, or (5) no location was logged by the GPS unit.

HRR concordance is similarly labeled but with the following differences: (1) yes, an HRR event corresponds to this entry, (2) yes an HRR event can be matched to this retrospective entry, (3) no, an HRR event does not correspond to this entry, or (4) no HR (bpm) data were logged during (within two minutes before or after timestamp/stated time) this entry. Additionally, the table includes a brief description of activity and constraint reported by participant, [A] – authoritative, [B] – biological, or [C] – coupling. In cases where the entry information revealed thoughts or events inconsistent with the reported constraint or implies an additional constraint, the author assigned an

expert alternate constraint designation of [A] – authoritative, [B] – biological, [C] – coupling, physical activity, excitement, or stimulant. The table approach served to summarize the shared and divergent findings of the two measurement tools.

***Correlation Coefficient Statistics***

The correlation design of this research does not have participants randomly assigned to groups. Research variables were not intentionally manipulated, rather data was collected on several variables during the training sessions, field monitoring, and focus groups. "…there are a number of different types of correlation coefficients, the most commonly used in social science is the Pearson product-moment correlation coefficient" (Urdan 2005, 75). Correlation analyses were performed to measure how strongly different variables relate to one another (Pagano and Gauvreau 2000; Urdan 2005). The correlation statistics, Pearson's product-moment correlation coefficient (Pearson's *r*), Kendall's tau-b, and Spearman's rho were the best fit for the data collected in this study due to a small, non-random sample, and the lack of adherence to some statistic parameters.

Pearson's *r* was computed to quantify the magnitude and direction of the relation between variables. To utilize this statistic the variables must be paired and measured on an interval or ratio scale, also known as continuous variables (Urdan 2005). Nonparametric statistics, which include Kendall's tau-b, and Spearman's rho are defined as, "a group of statistics that are not tied to assumptions common to parametric statistics, including normally distributed data and homogeneity of variance" (Urdan 2005, 166).

The strength of research design employing correlation is that it is often easier to conduct than experimental research due to lack of experiment controls and group divisions; easy inclusion of numerous variables allow for examination of the variables simultaneously (Pagano and Gauvreau 2000; Urdan 2005). Correlation approach's primary drawback is that the lack of control inherent in collecting data on several concurrent data variables in a sample of convenience underscores relationships but does not allow for drawing conclusions regarding causative associations between variables (Pagano and Gauvreau 2000; Urdan 2005).

SPSS PASW Statistics 18 (IBM) software was utilized for the statistical analyses of research data. The correlation analyses were performed with two-tailed tests of significance at a minimum of 95 percent confidence levels. Bivariate correlations, Kendall's tau-b, and Spearman's rho were done to separately quantify the concordance between audio self-reported HRR events and monitored HRR events, and between audio self-reported locations and GPS logged locations. Pearson's r was used to discern relation between tailed/discrete HRR episodes and the overall occurrence of category (1) HRR events. It was also used to evaluate the association between HRR and SSI total scores, SSI stressor/reaction scores, and HRR time ranges.

**Student-Life Stress Inventory**

Gadzella's (1991, 1994) Student-Life Stress Inventory (SSI) (Appendix F) is evaluated as "a moderately reliable and valid measure of students' stress on nine categories studied" (Gadzella 1994, 401). Both Cronbach Alpha and Pearson product-

moment correlation analyses were run to estimate the reliability of the inventory, even when split into groups of all subjects; men and women equaling 0.71 or greater (Gadzella 1994; Gadzella and Baloglu 2001). The metric is a static stress inventory that examines stressor categories and the students' type of reaction expression. A total of fifty-one stress related questions are grouped into five sections (Gadzella, Fullwood, and Tomcala 1992). The stressor categories are frustration (daily hassles, failure, and lack of resources), conflict (desirable and undesirable), pressure (deadlines, overload, and interpersonal relationships), changes (unpleasant, too many), and self-imposed (competitiveness, worrying, and procrastination) impetuses (Gadzella 1991, 1994). Students' reactions to stressors fall under four types: physiological (nervousness, ulcers, headaches, exhaustion), emotional (anxiety, fear, anger, guilt depression), behavioral (crying, abusing self and/or others, smoking, attempting suicide, separating oneself from others), and cognitive (analyzing the stressful situations and the strategies used in coping with stress) (Gadzella 1991, 1994). The inventory uses a 5-point Likert scale (1 = never, 2 = seldom, 3 = occasionally, 4 = often, and 5 = most of the time) for participants to rate each of the items (Gadzella 1991). The inventory produces three types of scores; first, the participants' initial perception of being either mildly, moderately, or severely stressed; second, a value for each of the categories; and third, a total stress value, which can be subdivided into the stressor and reaction scores.

### *Sensitivity and Specificity*

Testing the sensitivity and specificity of the calculated HRR for each participant and the accompanying stressor reports from the audio diaries was accomplished through comparison with the Student-Life Stress Inventory (SSI), a valid stress measure created by Gadzella (1991, 1994). Sensitivity is the proportion of people with disease, in this case stress response, who have a positive test result, and specificity is the proportion of people without disease, not experiencing stress, who have a negative test result. During training participants completed the SSI for later comparison with research results.

# CHAPTER IV

# ANALYSIS AND FINDINGS

How individuals interact with their surroundings is a complex subject. Capturing the spatiotemporal trajectory of a person's daily path is a component of the complexity, but when seeking to identify and understand the factors contributing to a cognitive health exposure, such as stress, information is required beyond time and space. Stress manifests in physiological changes, including heart rate variation, skin temperature increase, blood pressure fluctuation, changes in body chemistry (cortisol levels), and other alterations. In order to capture both objective and subjective reports of stress exposure within the field parameters of students' daily lives, several measures were used in concert. To collect empirical data that was not dependent on participant accounting or ability to recall participant location, wristwatch GPS units were used chronologically during the testing periods.

When adequate satellite triangulation is available, the GPS/HR units gave geographical coordinates within 5 meters (Appendix I). The GPS, synched with the heart rate sensor strap worn by each participant, provided geo-referenced and time-stamped heart rate data in the form of bpm. Using the heart rate data, heart rate reactivity (HRR) was calculated to assess episodes when participants' HR exceeded their testing mean. Exceeding the mean for the duration of several seconds in repetition or several minutes or more is an indicator of a stressful episode. HRR is a useful indicator of stress exposure but it is not a definitive measure of psychological stress.

In order to discern whether HRR calculations are attributable to psychological or physical stress, participant accounts were collected through audio diaries. The use of digital audio diaries made it convenient for students to record important information while on the go. Pilot study results and feedback pointed to mobility being a key factor in encouraging timely, and thus more accurate, diary accounts. Participant audio diary accounts have two main purposes: first, and arguably the most important, is to distinguish whether HRR is due to psychological or physical stress, and second, to describe socio-environmental situations that cause stress and categorize their stressor source using Hagerstrandian constraints. A secondary use of audio diary accounts is to identify confounding HR factors outside of physical stress, such as stimulants, excitement, and medication.

The audio diary accounts are the raw data for the qualitative coding analysis. Coding (labeling) participant entries helps to identify central themes related to stress exposure both individually and collectively. In addition, linking information from the participant diaries to their spatiotemporal paths displays a stress landscape, places where individuals experience stress and the socio-environmental factors that are associated with dynamic cognitive processes.

GeoTime is a visualization/analysis tool that allows for easy manipulation and display of spatiotemporal data sets. The integration of participant accounts with spatiotemporal data in a 3D environment, in measurement terms, highlights stress exposure at an individual level recorded in both the objective and subjective data set.

The data collected from participants can be put into four categories, based on level of completeness. Complete data collection consists of GPS, HR, and audio measurement for all three monitoring sessions, but some participants logged only HR and audio or audio data alone (see Table 1). Four participants finished the study but due to user error no locational (GPS) data were collected for them, only HR and audio entries. Two participants recorded no locational or heart rate data but did complete extensive audio diary accounts. One participant (214) recorded no useable data and it is unclear whether this was due to an inability to use the equipment correctly or a malfunction with one of the GPS units. However, all of the students completed the participant and SSI surveys during training. In summary, there are results of varying levels of completeness for twenty-two out of the twenty-three participants who attended the training sessions during the Fall semester of 2009 (see Table 1).

**Table 1.** The number of sessions completed and the type of data collected for each participant

| ID | Audio, GPS, and HR | HR and Audio | Audio | None |
|---|---|---|---|---|
| 201 | 3 sessions | | | |
| 202 | 1 session | 2 sessions | | |
| 203 | | | 3 sessions | |
| 204 | 3 sessions | | | |
| 205 | | | 3 sessions | |
| 206 | | 3 sessions | | |
| 207 | 1 session | 2 sessions | | |
| 208 | 1 session | 2 sessions | | |
| 209 | 1 session | 1 session | | |
| 210 | 1 session | 2 sessions | | |
| 211 | 3 sessions | | | |
| 212 | | 3 sessions | | |
| 213 | 1 session | 2 sessions | | |
| 214 | | | | X |
| 215 | | 3 sessions | | |
| 216 | 3 sessions | | | |
| 217 | | 3 sessions | | |
| 218 | 1 session | 2 sessions | | |
| 219 | 1 session | 2 sessions | | |
| 220 | 3 sessions | | | |
| 221 | 2 sessions | 1 session | | |
| 222 | 3 sessions | | | |
| 223 | 3 sessions | | | |

## Feasibility of Research Method

### *Heart Rate Reactivity*

The data collected by the GPS with synced heart rate monitors show that each participant with logged HR records experienced several episodes of heart rate reactivity. HRR episodes differed in duration, ranging from less than a minute to more than 30 minutes in length depending on the student and the situation (see Table 2). The following report of HRR is not correlated with participant awareness of stress or factors that would raise the rate; that correlation will be addressed later. These are simply calculated scores that are independent of explanatory audio diary accounts.

Using calculated HRR above, individual participant means for the three monitoring sessions (15 hours) provides an objective look at the frequency of unqualified stress exposure. In this research sample, HRR episodes range between 34 and 618 depending on the individual (see Table 2). The total number of heart rate reactivity episodes is divided into six time categories: less than a minute (a), 1 to 5 minutes (b), greater than 5 to 10 minutes (c), greater than 10 to 15 minutes (d), greater than 15 to 30 minutes (e), and greater than 30 minutes (f). Most of the heart rate reactivity episodes recorded lasted for less than 1 minute. Episodes lasting between one and 5 minutes had the next highest frequency rate. The frequency of episodes based on time ranges is correlated to the total number of HRR occurrences (Figure 4); the lower time divisions a-c occur with a higher frequency and have a much higher, statistically significant correlation than the d-f time divisions. Heart rate reactivity episodes declined dramatically in the greater than 5 to 10 minute category and remain low in the greater than 10 to 15 minute, greater than 15 to

30 minute, and greater than 30 minute durations (see Table 2). The heart rate reactivity calculations show that episodes greater than 10 minutes in duration happened with low frequency.

### *Discrete Versus Tailed Heart Rate Reactivity*

The detailed temporal data collection reveals two types of HRR events, discrete and tailed. HRR events that are discrete have a definite, observable, beginning and ending time. A timestamp is associated with each location and HR (heart rate) logged by the GPS/ monitoring equipment. The temporal component of the data thus reliably helps to distinguish one HRR event from another. Tailed events are the second type of episode and they represent HRR events that taper off before ending. An HRR event that relates to another episode by occurring 60 seconds or closer is tailed and assumes that the source of the stress exposure is the same as the previous or following event. Within the context of this study tailed HRR events are events that build up or taper off, and so the elevated heart rates are considered to be related to each other; connected to the same stress exposure.

**Table 2.** Heart rate reactivity episodes recorded by the GPS/HR monitors

| ID | # of Sessions with HR | Total HRR | HRR (a) < 1min | HRR (b) 1-5min | HRR (c) >5-10min | HRR (d) >10-15min | HRR (e) >15-30min | HRR (f) >30min |
|---|---|---|---|---|---|---|---|---|
| 201 | 3 | 267 | 209 | 53 | 2 | 3 | 0 | 0 |
| 202 | 3 | 421 | 324 | 75 | 12 | 10 | 0 | 0 |
| 204 | 3 | 618 | 498 | 91 | 21 | 4 | 3 | 1 |
| 206 | 3 | 359 | 277 | 67 | 9 | 2 | 4 | 0 |
| 207 | 3 | 278 | 248 | 24 | 4 | 0 | 0 | 2 |
| 208 | 3 | 165 | 120 | 34 | 5 | 4 | 1 | 1 |
| 209 | 2 | 69 | 53 | 14 | 1 | 1 | 0 | 0 |
| 210 | 3 | 208 | 144 | 47 | 8 | 5 | 4 | 0 |
| 211 | 3 | 260 | 213 | 39 | 6 | 0 | 2 | 0 |
| 212 | 3 | 360 | 298 | 45 | 13 | 1 | 3 | 0 |
| 213 | 3 | 506 | 413 | 71 | 15 | 2 | 3 | 2 |
| 215 | 3 | 503 | 425 | 63 | 8 | 1 | 5 | 1 |
| 216 | 3 | 53 | 41 | 11 | 0 | 1 | 0 | 0 |
| 217 | 3 | 34 | 27 | 5 | 0 | 1 | 1 | 0 |
| 218 | 3 | 430 | 319 | 91 | 9 | 5 | 6 | 0 |
| 219 | 3 | 489 | 392 | 84 | 7 | 4 | 1 | 1 |
| 220 | 3 | 227 | 154 | 53 | 13 | 7 | 0 | 0 |
| 221 | 3 | 347 | 256 | 73 | 13 | 1 | 3 | 1 |
| 222 | 3 | 410 | 346 | 53 | 10 | 1 | 0 | 0 |
| 223 | 3 | 379 | 330 | 45 | 4 | 0 | 0 | 0 |

| | | HRR | |
|---|---|---|---|
| HRR | Pearson Correlation | 1 | |
| | Sig. (2-tailed) | | |
| | N | 20 | |
| HRR a | Pearson Correlation | .993** | |
| | Sig. (2-tailed) | .000 | |
| | N | 20 | |
| HRR b | Pearson Correlation | .878** | |
| | Sig. (2-tailed) | .000 | |
| | N | 20 | |
| HRR c | Pearson Correlation | .751** | |
| | Sig. (2-tailed) | .000 | |
| | N | 20 | |
| HRR d | Pearson Correlation | .183 | |
| | Sig. (2-tailed) | .439 | |
| | N | 20 | |
| HRR e | Pearson Correlation | .435 | |
| | Sig. (2-tailed) | .055 | |
| | N | 20 | |
| HRR f | Pearson Correlation | .389 | |
| | Sig. (2-tailed) | .090 | |
| | N | 20 | |
| ** Correlation is significant at the 0.01 level (2-tailed). | | | |

**Figure 4.** Pearson's *r*: HRR totals and frequency within HRR time ranges.

Out of the 103 category (1), HRR episodes 23 (22 percent) are discrete events and 80 (78 percent) are tailed events (see Table 3). The participants with the highest number of HRR episodes are 218 (23), 204 (12), 222 (12), 219 (11), and 221 (10) (see Table 3). These participants account for 68 (66 percent) of the category (1) HRR events. The five participants with the highest HRR rates, comprise fifty-two tailed events, which is 65

percent of tailed HRR and sixteen discrete events, which is 70 percent of discrete HRR episodes (see Table 3).

**Table 3.** Discrete versus tailed HRR category (1) events only

| Participant | HRR (1) | Discrete | Tailed |
|---|---|---|---|
| 201 | 1 | 1 | 0 |
| 202 | 3 | 0 | 3 |
| 204 | 12 | 3 | 9 |
| 206 | 7 | 3 | 4 |
| 207 | 6 | 1 | 5 |
| 208 | 1 | 1 | 0 |
| 213 | 3 | 0 | 3 |
| 215 | 7 | 0 | 7 |
| 216 | 2 | 0 | 2 |
| 217 | 1 | 0 | 1 |
| 218 | 23 | 4 | 19 |
| 219 | 11 | 3 | 8 |
| 220 | 3 | 1 | 2 |
| 221 | 10 | 4 | 6 |
| 222 | 12 | 2 | 10 |
| 223 | 1 | 0 | 1 |
| Total | 103 | 23 | 80 |

Discrete and tailed HRR episodes related to stress exposure has not currently been documented in stress measurement literature. Field collection of detailed HR data with associated temporal data reveals these two types, discrete and tailed, of HRR events. A key difference between the two HRR types is that discrete episodes cluster in lengths from 1 second to 5 minutes while tailed event occurrences are spread evenly from 1 second to more than 30 minutes (see Table 4 and Table 5). According to the data stress exposures are more often expressed as tailed HRR events than discrete HRR episodes.

**Table 4.** Discrete HRR events of category (1) concordance only

| Participant | HRR (1) Discrete | HRR < 1min | HRR 1-5min | HRR >5-10min | HRR >10-15min | HRR >15-30min | HRR >30min |
|---|---|---|---|---|---|---|---|
| Total | 23 | 13 | 8 | 1 | 0 | 0 | 1 |

**Table 5.** Tailed HRR events of category (1) concordance only

| Participant | HRR (1) Tailed | HRR < 1min | HRR 1-5min | HRR >5-10min | HRR >10-15min | HRR >15-30min | HRR >30min |
|---|---|---|---|---|---|---|---|
| Total | 80 | 11 | 15 | 15 | 12 | 14 | 13 |

Note: Time ranges for tailed events represent the total HRR time for the initial event and its related tails.

***Discrete Versus Tailed Heart Rate Reactivity Analyses***

Pearson's product-moment correlation coefficient (Pearson's *r*) was computed to quantify the magnitude and direction of the relation between discrete/tailed HRR episodes and the overall occurrence of category (1) HRR events among participants. The correlation analyses were performed with two-tailed tests of significance at a minimum of 95 percent confidence levels. The relation of discrete HRR events and tailed HRR events to overall HRR category (1) occurrences differs. Discrete HRR events return a high correlation coefficient of 0.802 with a p value of 0.000 (Figure 5). A p = 0.000 indicates that there is an extremely low probability of obtaining the 0.802 coefficient for the sample (N = 16) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan 2005). The coefficient is also statistically significant at 0.01, the 99 percent confidence interval (Figure 5). Concordance among the participants between category (1) HRR episodes and discrete HRR is high.

Tailed HRR occurrences have a very high, near perfect, correlation trend to HRR category (1) totals. Tailed HRR events return a correlation coefficient of 0.983 with a p value of 0.000 (Figure 5). Concordance among the participants between category (1) HRR episodes and tailed HRR is very high.

The relation between discrete HRR and tailed HRR occurrences was also computed using Pearson's *r* correlation analysis. The statistic returned a mid-level correlation coefficient of 0.679 with a p value of 0.004 (Figure 5). A p = 0.004 indicates that there is a low probability of obtaining the 0.679 coefficient for the sample (N = 16) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan

2005). Concordance among the participants between discrete HRR and tailed HRR episodes is medium.

| | | Discrete | Tailed | HRR (1) |
|---|---|---|---|---|
| Discrete | Pearson Correlation | 1 | .679** | .802** |
| | Sig. (2-tailed) | | .004 | .000 |
| | N | 16 | 16 | 16 |
| Tailed | Pearson Correlation | .679** | 1 | .983** |
| | Sig. (2-tailed) | .004 | | .000 |
| | N | 16 | 16 | 16 |
| HRR (1) | Pearson Correlation | .802** | .983** | 1 |
| | Sig. (2-tailed) | .000 | .000 | |
| | N | 16 | 16 | 16 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Figure 5.** Pearson's *r*: HRR (1) correlation to discrete and tailed HRR.

### *Student-Life Stress Inventory Associations to Heart Rate Reactivity*

Pearson's r statistic was also utilized to quantify the association between the HRR and SSI total scores, stressor scores, and reaction scores. The question to be answered is do these two different measurements for stress exposure have a positive relation. The Student-Life Stress Inventory is a written survey taken by students to assess daily contributors and reactions to stress. While heart rate reactivity is calculated by first gathering heart rate date from infield bio-monitoring equipment and then using individual bpm means to distinguish elevated rates. HR, and therefore HRR is collected as events are transpiring, the SSI is taken separate from life experiences. The correlation

analyses were performed with two-tailed tests of significance at a minimum of 95 percent confidence levels.

The negative correlation between HRR and SSI total score appears to highlight the divide between fundamentally different measurement methods for stress exposures, active and passive. SSI total scores and HRR events show a nonexistent, low level negative correlation coefficient of -0.273 with a p value of 0.245 (Figure 6). A p = 0.245 indicates that there is a relatively high probability of obtaining the -0.273 coefficient for the sample (N = 20) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan 2005). There is no trend of association between category SSI total scores and HRR episodes.

| | | SSI Score |
|---|---|---|
| SSI Score | Pearson Correlation | 1 |
| | Sig. (2-tailed) | |
| | N | 20 |
| HRR | Pearson Correlation | -.273 |
| | Sig. (2-tailed) | .245 |
| | N | 20 |

**Figure 6.** Pearson's *r*: SSI total score and HRR.

The lack of association evident when comparing SSI total score and HRR is echoed in the negative correlations between SSI stressor score and HRR and SSI reaction score and HRR (Figure 7). Conversely, both the stressor type and reaction type scores have a high correlation, as expected, to the Student-Life Stress Inventory total score. SSI

stressor scores return a high correlation coefficient of 0.855 and the reaction scores have a very high, near perfect, correlation coefficient of 0.950, both with a p value of 0.000 (Figure 7). A p = 0.000 indicates that there is an extremely low probability of obtaining the 0.855 or 0.950 coefficients for the sample (N = 20) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan 2005).

The coefficients are also statistically significant at 0.01, the 99 percent confidence interval (Figure 7). Concordance among the participants between SSI stressor/reaction scores and SSI total scores is quite high.

Additionally, a mid-level correlation between the stressor and reaction scores exists similar to the medium correlation between discrete and tailed HRR. The relation between stressor scores and reaction scores resulted in a correlation coefficient of 0.652 with a p value of 0.002 (Figure 7). A p = 0.002 indicates that there is a low probability of obtaining the 0.652 coefficient for the sample (N = 20) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan 2005). Concordance between SSI stressor and reaction scores is medium. Each component comprises half of the category designations for the SSI inventory; the stressor type identifying daily stress factors and the reaction type linking physical and mental responses to stress exposures.

| | | Stressor Score | Reaction Score |
|---|---|---|---|
| Stressor Score | Pearson Correlation | 1 | .652** |
| | Sig. (2-tailed) | | .002 |
| | N | 20 | 20 |
| Reaction Score | Pearson Correlation | .652** | 1 |
| | Sig. (2-tailed) | .002 | |
| | N | 20 | 20 |
| SSI Score | Pearson Correlation | .855** | .950** |
| | Sig. (2-tailed) | .000 | .000 |
| | N | 20 | 20 |
| HRR | Pearson Correlation | -.050 | -.369 |
| | Sig. (2-tailed) | .833 | .109 |
| | N | 20 | 20 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Figure 7.** Pearson's *r*: SSI scores (stressor, reaction, and total) and HRR.

### *Student-Life Stress Inventory*

The Student-Life Stress Inventory (SSI) is an index of statements that specifically concern student-life stress. There is a section of twenty-three statements that regard daily life stressors and a section of twenty-eight questions about students' reactions to the stressors that they encounter. Since the SSI is a validated psychometric for student stress assessment, the goal was to see if there is a correlation between SSI values and the number of HRR episodes experienced by the participants. Possibly because of the prospective nature of the HRR measure versus the retrospective reflection of the SSI, there was no noticeable relationship between high total percentage SSI score and high HRR counts. In this research population it is evident from the SSI values that the majority of participants consider themselves moderately stressed and that high percentage scores in the stressor type category of pressure, which is analogous to the

authoritative constraint, and high percentage scores in the stressor type category of self-imposed, which is analogous to the biological constraint, are prevalent.

**Table 6.** Student-Life Stress Inventory (SSI) results

| ID | Self-Assessed stress | SSI Percent | Stressor Percent | Reaction Percent | HRR (1) Count |
|---|---|---|---|---|---|
| 201 | moderate | 52.50 | 62.60 | 44.20 | 1 |
| 202 | moderate | 52.10 | 59.10 | 46.40 | 3 |
| 204 | mild | 47.40 | 65.20 | 32.80 | 12 |
| 206 | - | 60.30 | 70.40 | 52.10 | 7 |
| 207 | moderate | 52.10 | 60.80 | 45.00 | 6 |
| 208 | moderate | 48.60 | 57.30 | 41.40 | 1 |
| 209 | moderate | 58.03 | 71.30 | 47.10 | 0 |
| 210 | moderate | 72.90 | 78.20 | 68.50 | 0 |
| 211 | moderate | 45.40 | 56.50 | 36.40 | 0 |
| 212 | moderate | 54.50 | 60.00 | 50.00 | 0 |
| 213 | moderate | 52.10 | 65.20 | 41.40 | 3 |
| 215 | - | 50.50 | 67.80 | 36.40 | 7 |
| 216 | severe | 71.70 | 74.70 | 69.20 | 2 |
| 217 | - | 41.50 | 49.50 | 35.00 | 1 |
| 218 | mild | 59.60 | 61.70 | 57.80 | 23 |
| 219 | moderate | 52.10 | 66.08 | 40.70 | 11 |
| 220 | moderate | 58.03 | 66.80 | 51.40 | 3 |
| 221 | mild | 46.20 | 57.30 | 37.10 | 10 |
| 222 | moderate | 50.50 | 59.10 | 43.50 | 12 |
| 223 | moderate | 45.09 | 50.40 | 40.70 | 1 |
| Average | moderate | 54.12 | 62.76 | 47.07 | 5.15 |

## Hagerstrandian Constraints

### *Coding*

Qualitative analysis was performed on the transcripts from twenty-two participant audio diaries. Wave files were produced by the digital audio recorder used by each participant. The number of diary entry wave files recorded by each participant ranged between one and thirty-eight. Each entry was transcribed into a master file associated with the participant. Transcriptions included the digital time stamp that the recorder gave each file. Therefore, in addition to the verbal account of when experienced events took place, there is also a digital date and time associated with each diary entry.

Can the model of Hagerstrandian constraints (capability, coupling, authority) explain factors associated with college student stress? Coding analysis was performed using ATLAS.ti software. The transcript files were broken down into quotations that related to participant-stressed exposures. After identifying the pertinent quotations, each quotation was coded (labeled) using one or more of the twenty-one information categories (Figure 8). In ATLAS.ti, a grounded (Brown and Lloyd 2001) number is applied that indicates how often a particular code was used. The most-used labels were stress exposure (90), followed by academic (57), constraint identification (35), heart rate identification (28), physical stress (24), anticipated event stress (23), ‘B’ biological (22), ‘C’ coupling (18), and ‘A’ authoritative (18), and the remaining categories have a frequency ranging from 1 to 4 (Figure 8).

| Name | Grounded | Density |
|---|---|---|
| conflict | 3 | 1 |
| protocol issues | 3 | 3 |
| stimulant ingestion | 5 | 1 |
| reflection | 6 | 1 |
| physical ailment | 9 | 2 |
| Place Meaning | 9 | 1 |
| Combined - Psyc... | 10 | 2 |
| late | 10 | 1 |
| personal | 10 | 2 |
| stress reaction | 10 | 3 |
| perceived time sc... | 11 | 1 |
| equipment issues | 16 | 1 |
| 'A' Authoritative | 18 | 3 |
| 'C' Coupling | 18 | 3 |
| 'B' Biological | 22 | 3 |
| anticipated event... | 23 | 3 |
| physical stress | 24 | 1 |
| heart rate identifi... | 28 | 2 |
| contraint identific... | 35 | 4 |
| academic | 57 | 2 |
| stress exposure | 90 | 12 |

**Figure 8.** The code categories associated with the self-report audio diaries.

Once relevant quotations were identified and the appropriate codes were associated to those quotations, relational linkages (density) were drawn among the codes. Using the relational linkages helped to create a web that highlighted how different codes influenced each other. The relations produced by analysis are “is cause of,” “is part of,” and “is associated with” (Figure 9). After the relational linkages were established (Figure 8), the program tabulated the number of connections that existed among a given code and other codes. The number of linkages to other codes pointed to central ideas or themes within the transcripts. Among the codes used in this research, stress exposure had

the largest number of linkages, twelve. The other codes ranged in linkage densities between one and four (Figure 8).

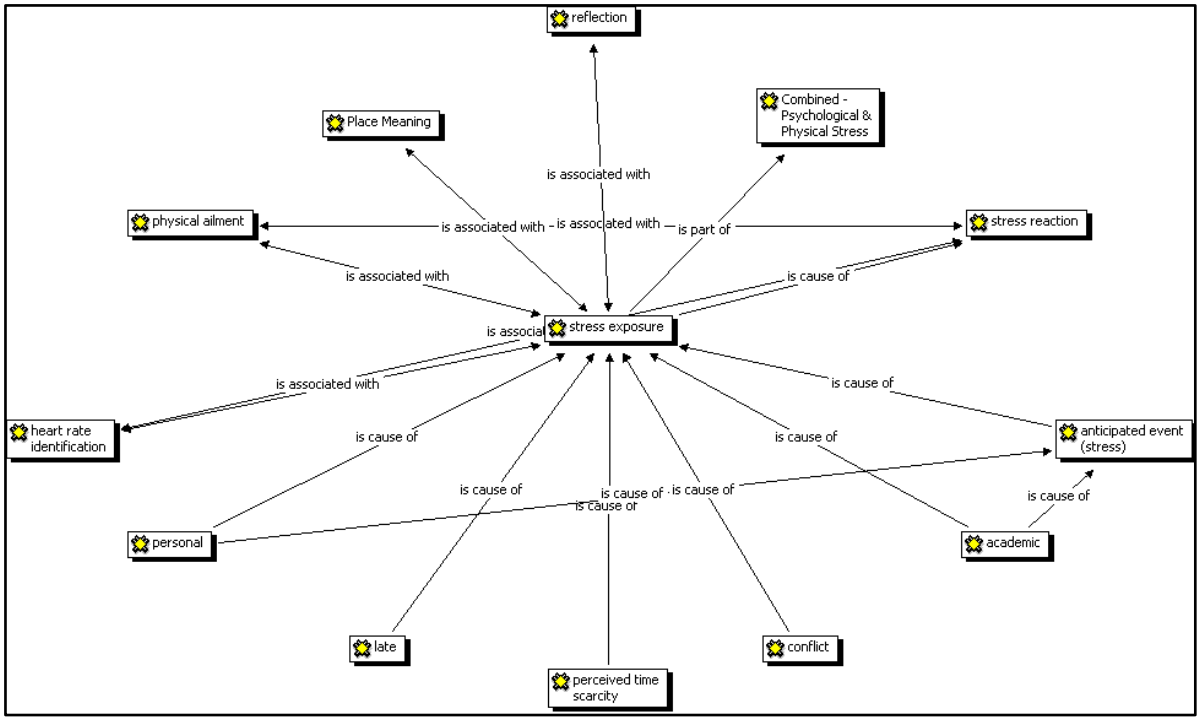



**Figure 9.** The relational links for the stress exposure code.

Stress exposure, the primary concept in this research, is supported by its high code usage frequency (Figure 8) and relational linkage centrality (Figure 9). The type of relational linkage that a factor has to the central theme of stress exposure signifies its importance in stressful experiences. Factors that are directly linked to stress exposure as "is cause of" are key components of student stress. Some of the "is cause of" variables (Figure 9) including being late for class (academic), perceived time scarcity, academic issues, personal, and anticipated events are explicitly highlighted in the spatiotemporal

narratives section as well as being echoed in responses about stressful experiences from the participant survey and focus group. Other factors are connected to stress exposure as "is associated with" and therefore are not primary but related variables. These associations (Figure 9) include place meaning, increased HR identification, and reflection and based on focus group discussions and reflective audio entries seem to be part of a growing awareness that is a by-product resulting from participating in this study. Two other important associations that are shown by the analysis of transcript data are academics "is cause of" stress reactions and academics "is cause of" stress produced by anticipation of events (Figure 9). Both of these associations highlight the fact that academic pressures and responsibilities are explicitly identified by students as stress exposures.

**Spatiotemporal Narratives**

Are the instances of stress in an individual student's life associated with specific locations or a chronological sequence of locations? Do an individual's stressors have a temporal/locational pattern? How does an individual's perception of place influence his or her stress level? The next step was linking the qualitative audio diary entries to the geo-referenced HRR events. 3D maps created in GeoTime from the collected spatiotemporal data are connected to the diary entry accounts of the participants to put their stressors into context. The map and audio accounts illustrate representative parts of the story of each student's stress exposure and through the utilization of daily path trajectory give a sense of heart rate reactivity patterns by pinpointing reported stressors

or logged events that went unreported. Each participant's stress exposures narrative is elucidated via quotes, maps (Figures 10 - 116), map explanations, and trajectory data interpretation to provide a broader context.

The complex narratives in this section have been simplified into a matrix (see Table 7) showing the presence or absence of stress exposure constraints and socio-environmental contexts affecting each participant. Hagerstrandian constraints and physical activity comprise the stress exposure categories. Social-environmental context categories were derived directly from the types of situations and places that students most often associated with stressors in the selected audio diary entries. Data in the matrix is based only on audio entries and maps included in the narrative section. The stress exposure categories are [A] authoritative, [B] biological, [C] coupling, and [P] physical activity. The socio-environment context categories are Cl (classroom/lab), Hd (home/dorm), Tp (time pressure), Ss (social setting), Tr (transit), Wo (work), Ex (exam), Pr (personal relationship), St (studying), and academic other.

**Table 7.** Presence of stress exposures and socio-environment factors from quotes and mapped information

| Participants | Stress exposure | | | | Socio-environment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [A] | [B] | [C] | [P] | Cl | Hd | Tp | Ss | Tr | Wo | Ex | Pr | St | Academic Other |
| 201 | 1 | 1 | | 1 | 1 | | 1 | | 1 | | 1 | | 1 | 1 |
| 202 | | 1 | | 1 | 1 | 1 | 1 | | | 1 | | | | |
| 204 | 1 | 1 | | 1 | | | 1 | 1 | 1 | | 1 | | 1 | 1 |
| 206 | | 1 | | 1 | 1 | | | | | | 1 | | 1 | |
| 207 | | 1 | 1 | 1 | | 1 | 1 | | | | 1 | | 1 | |
| 208 | 1 | 1 | | 1 | | | 1 | | | | 1 | | | |
| 209 | | | | 1 | | | | | | | | | 1 | |
| 210 | 1 | 1 | 1 | 1 | | 1 | | 1 | | | 1 | 1 | | 1 |
| 211 | 1 | 1 | | 1 | | | | | | | 1 | | | |
| 212 | 1 | 1 | | 1 | | | 1 | | | | 1 | | | |
| 213 | 1 | | | 1 | | | 1 | | | | 1 | | | |
| 215 | 1 | 1 | | | | 1 | 1 | | | | 1 | | 1 | 1 |
| 216 | 1 | | | 1 | 1 | | | | | | 1 | | 1 | |
| 217 | 1 | 1 | | 1 | | | | | | | 1 | | 1 | |
| 218 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 |
| 219 | 1 | 1 | | | 1 | 1 | 1 | | | | 1 | | 1 | 1 |
| 220 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 |
| 221 | 1 | | | 1 | 1 | | 1 | | 1 | | 1 | | 1 | |
| 222 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 |
| 223 | 1 | | | 1 | | | | | | 1 | | | | 1 |
| Total | 15 | 15 | 5 | 18 | 9 | 8 | 13 | 3 | 6 | 4 | 17 | 3 | 12 | 9 |

Note: The stress exposure constraints [A] authoritative and [B] biological both have a score of 15; 75 percent of the participants connected [A] and [B] to stressors. Physical activity [P] was a part of most students' day. Socio-environmental contexts reported as factors involved in stressful experiences were often academic in nature. The highest rating academic contexts are Cl (classroom/lab) = 9, Tp (time pressure) = 13, Ex (exam) = 17, St (studying) = 12, and academic other = 9.

***Participant 201***

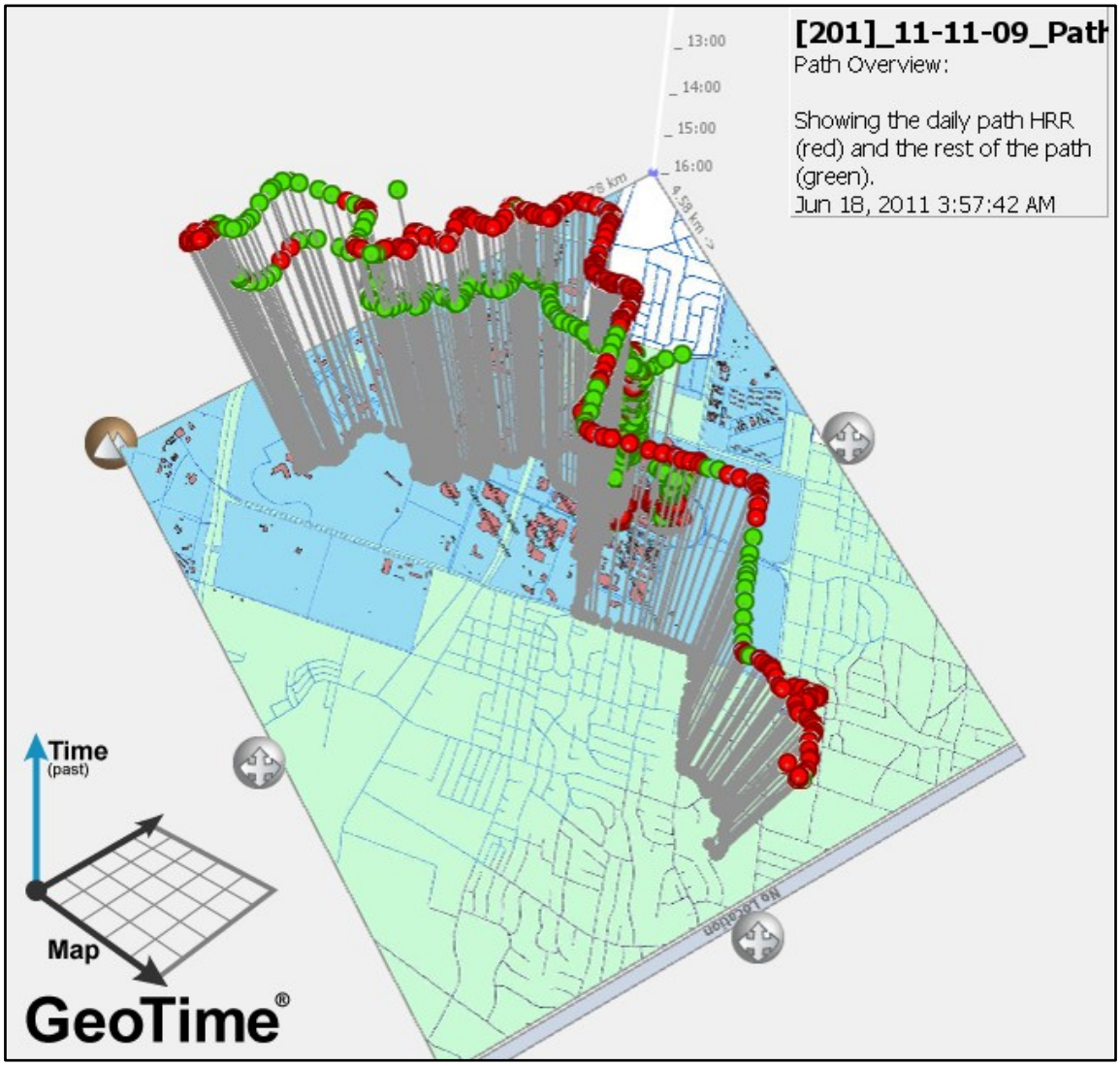



**Figure 10.** Participant 201: map of 11/11/09 daily path.
Note: HRR events are marked in red.

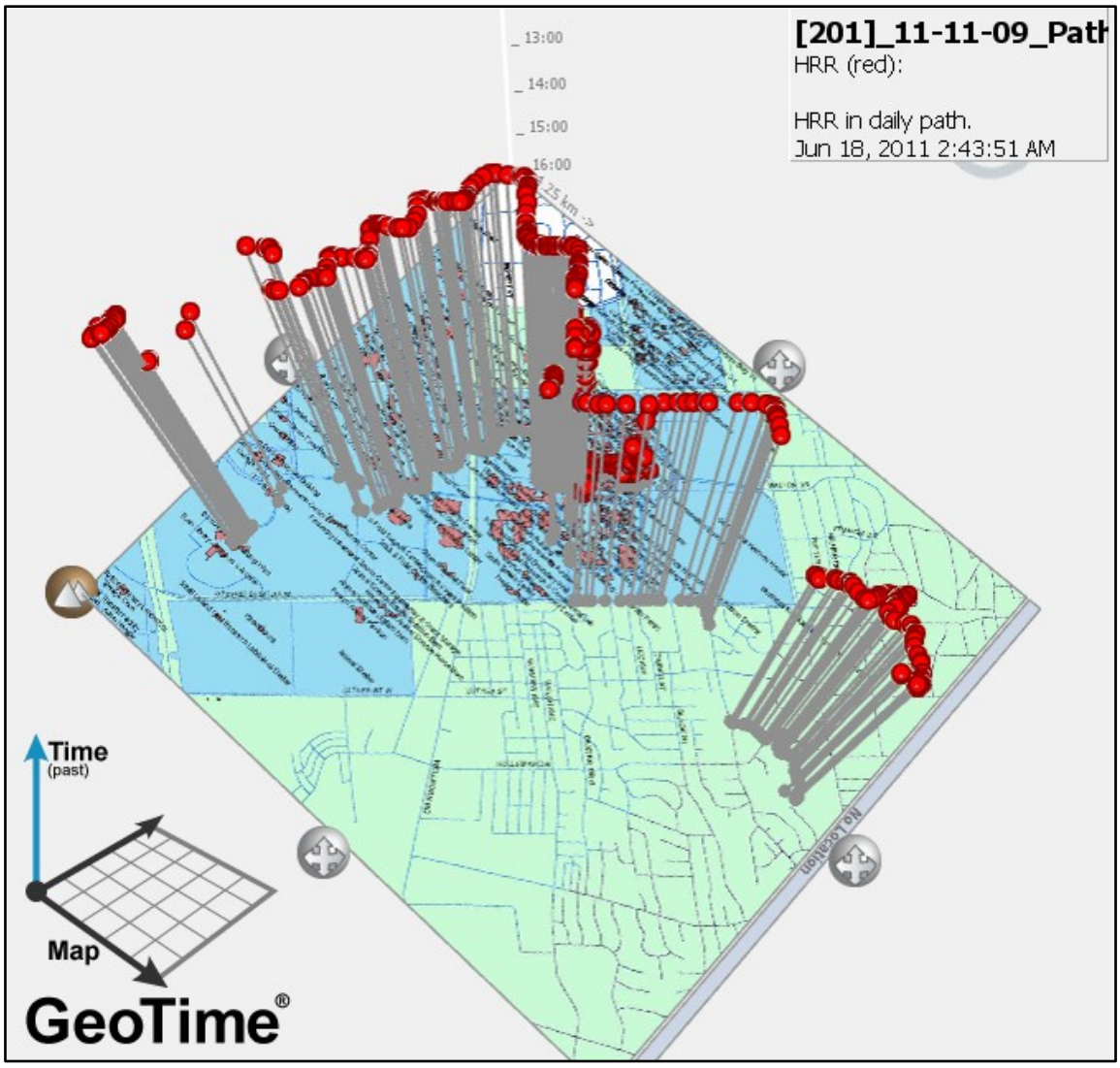



**Figure 11.** Participant 201: map of 11/11/09 logged HRR events.

The daily path for this participant displays HRR events primarily at home getting ready to head to campus, when in transit (walking around campus), and at particular academic locations on campus (Figures 10 and 11). For example, the participant experiences HRR events associated with physical activity (walking) and while attending a Biology lab that usually causes stress. *"...like I said in the morning I went over to class*

*at the George Bush Library …then left from there and went over to Heldenfels for a biology lab* (Figure 12). *Which went actually pretty good um usually I'm all stressed out and stuff. But today it was a good um good lab it was fun and stuff so I was able to be okay"* (Entry 3: 11/11/09 @ 18:21).

Later in the day she details HRR events that characterized the end of the first monitoring period. *"So um towards the end there might be a change in heart rate because I was really stressed out like towards the end. I went over to the O&M building to check on one of my grades for the test I had taken um two days before* (Figure 13). *So I was really stressed out about that and I also had to go and do a lot of things at the O&M building. I had to go to chat with one of my advisors um and then I had to go check with one of my professors. So I was like running around and just really stressed out trying to finish everything and um get everything done within in a certain amount of time. So I was really trying to get everything done in time. So I really got myself stressed out"* (Entry 3: 11/11/09 @ 18:21). Even though she doesn't explicitly give a constraint related to this experience of stress it is clear from her diary account that there is a feeling of urgency and pressure to accomplish academic tasks in a certain amount of time. Later in the same audio entry she returns to the discussion of time as a major factor in her biggest stressor of the day.

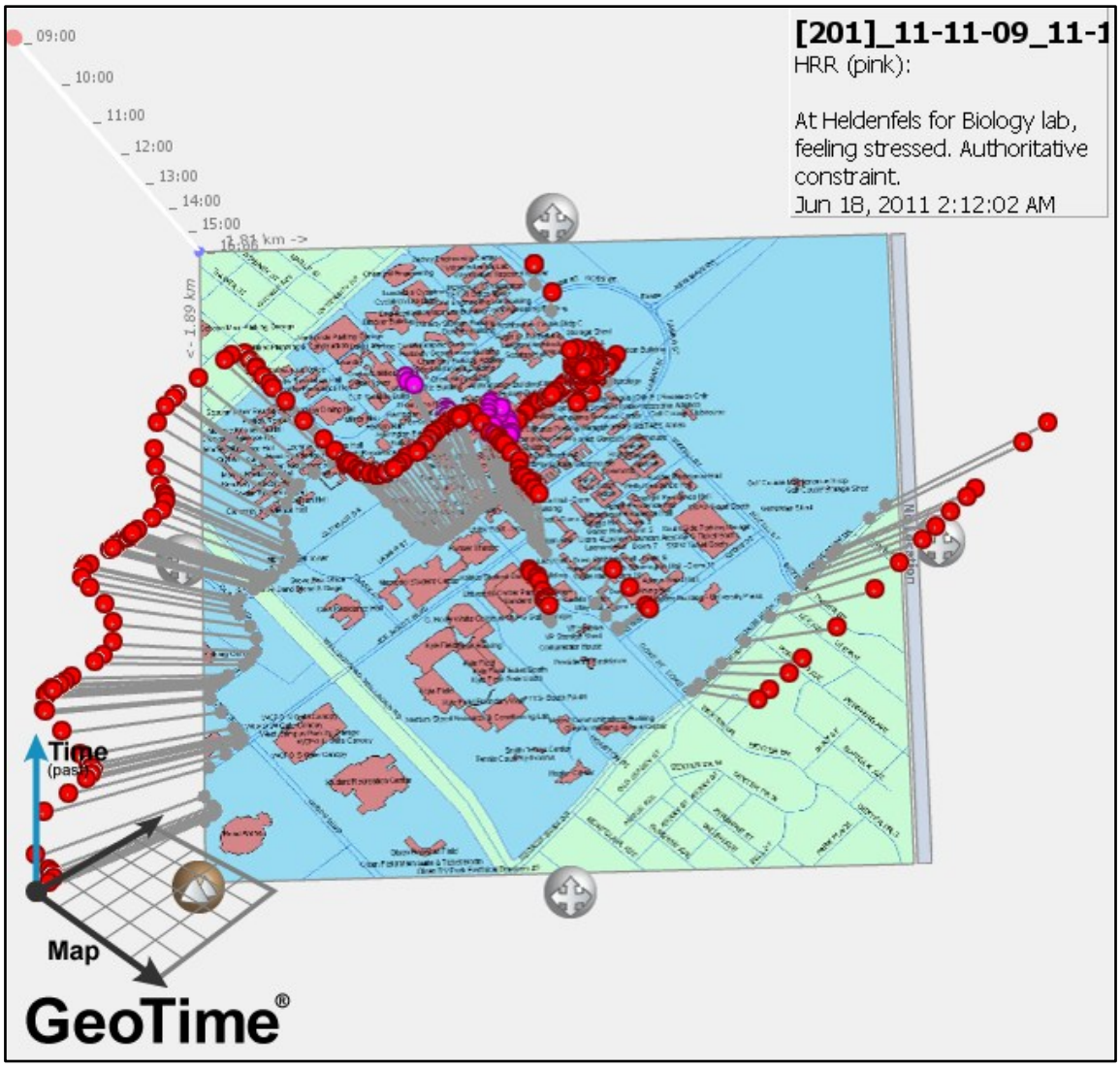



**Figure 12.** Participant 201: map of HRR events (11:00–12:00).
Note: HRR events are in pink and shows part of the participant's walk from the Bush Library area to Heldenfels for a Biology lab.

"*And what else and then over to the O&M building and that's when everything just like started happening. I had to get things done with the counselor well advisor and then I had to go downstairs to like see one of my professors and up again to the advisor. So it was a lot of pressure that last the last maybe 30 minutes of the first test the five-hour*

*test. So overall everything was good though just that stressing period toward the end"* (Entry 3: 11/11/09 @ 18:21). Due to the emphasis put on a perceived lack of time to accomplish everything, this HRR event is labeled as a biological constraint.

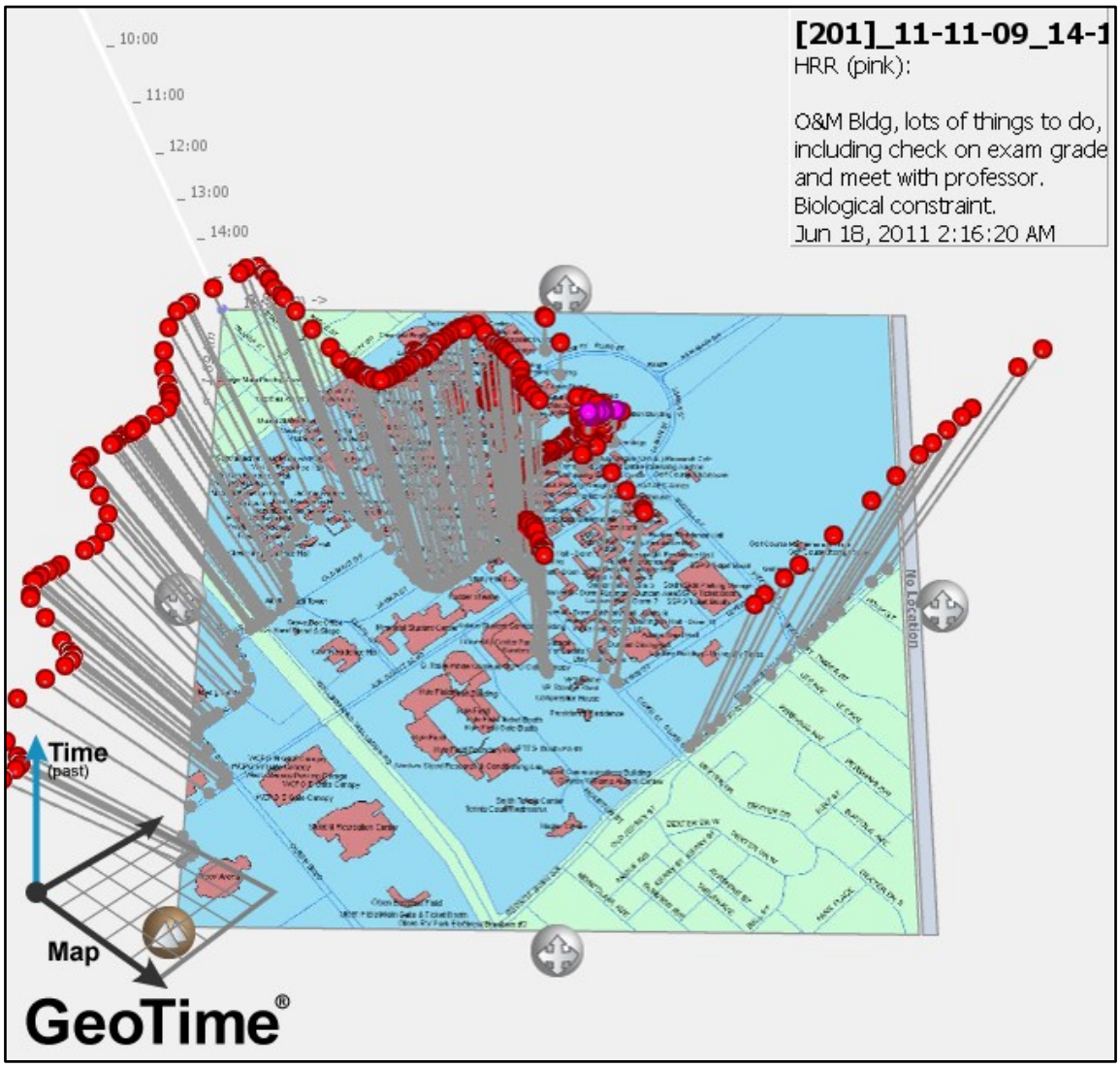



**Figure 13.** Participant 201: map of HRR events (14:00–15:00).
Note: HRR events are in pink and show a stressful period at the O&M Building toward the end of the first monitoring session.

The participant was keenly aware of her time of stress and noted that her HR decreased to what she categorized as average after accomplishing the tasks and leaving the O&M building. "*So towards the end um I left O&M building, then I went over to review session* (Figure 14) *and that's when my heart rate dropped again to I would say is about average, what it really is you know"* (Entry 3: 11/11/09 @ 18:21). During the last hour of the monitoring period the participant experienced twenty-five HRR episodes ranging from several seconds to several minutes (Figure 15). The data recorded by the GPS unit/HR monitor correspond in geographic location and HRR readings with the participant's audio entry. *"About to start the second day of testing* (Figure 16). *Um I am feeling extremely stressed out. I have a biology test today"* (Entry 4: 11/12/09 @ 9:08). Her stress level assessment describes disruptions from the previous night, which are outside of the monitoring session but informative regarding the physical affects beyond HRR. "*I really need to do good on it and I'm stressing out since last night. Um went to sleep around 4…3 AM this morning. Woke up at 8:30 so I'm stressed out. I haven't gotten much sleep and um gotta run to the bus, catch the bus,* (Figure 17) *get to school"* (Entry 4: 11/12/09 @ 9:08).

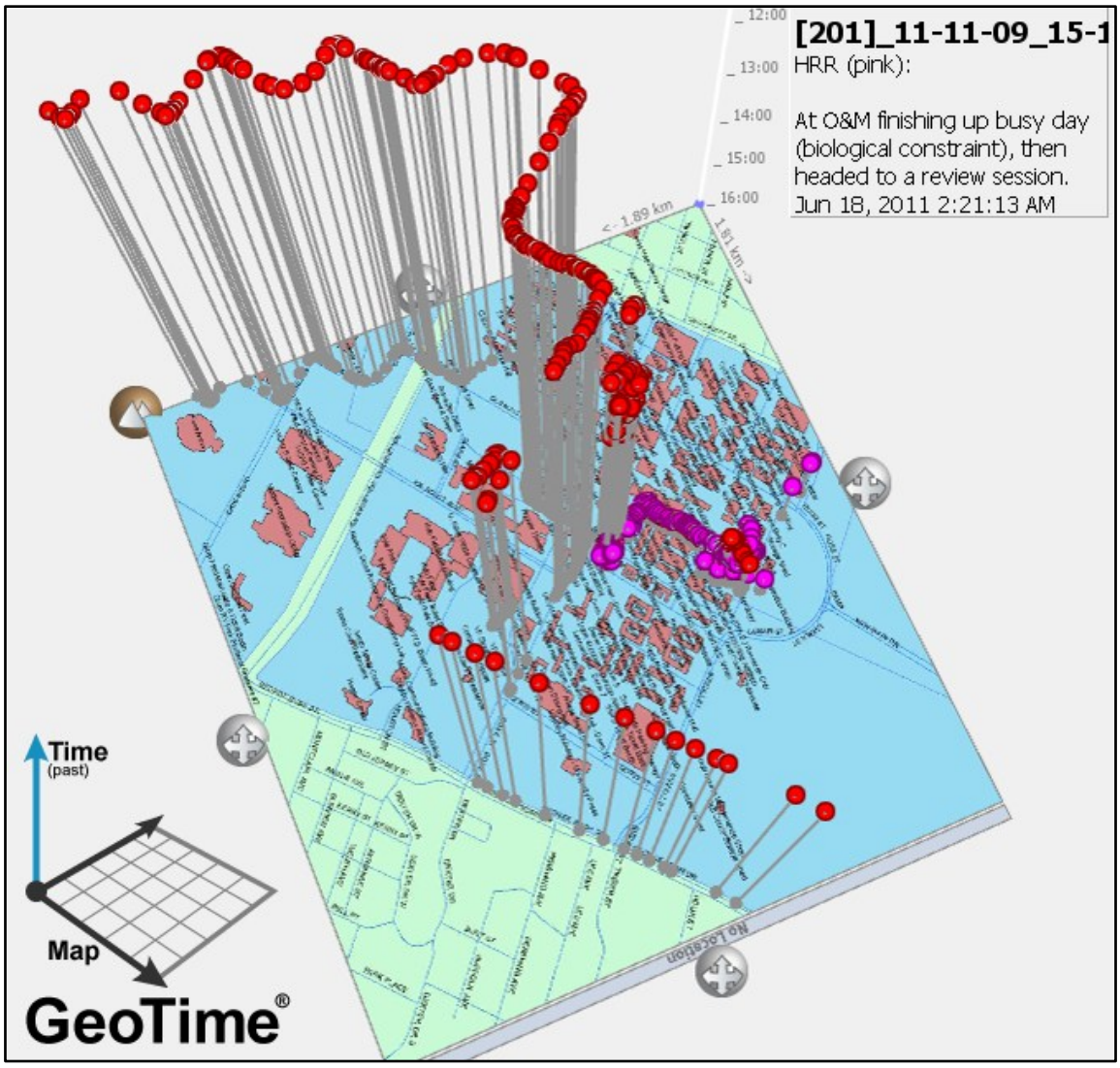



**Figure 14.** Participant 201: map of HRR events (15:00-16:00).
Note: HRR events are in pink and show the end of an episode at the O&M building and then the participant heads to a review session.

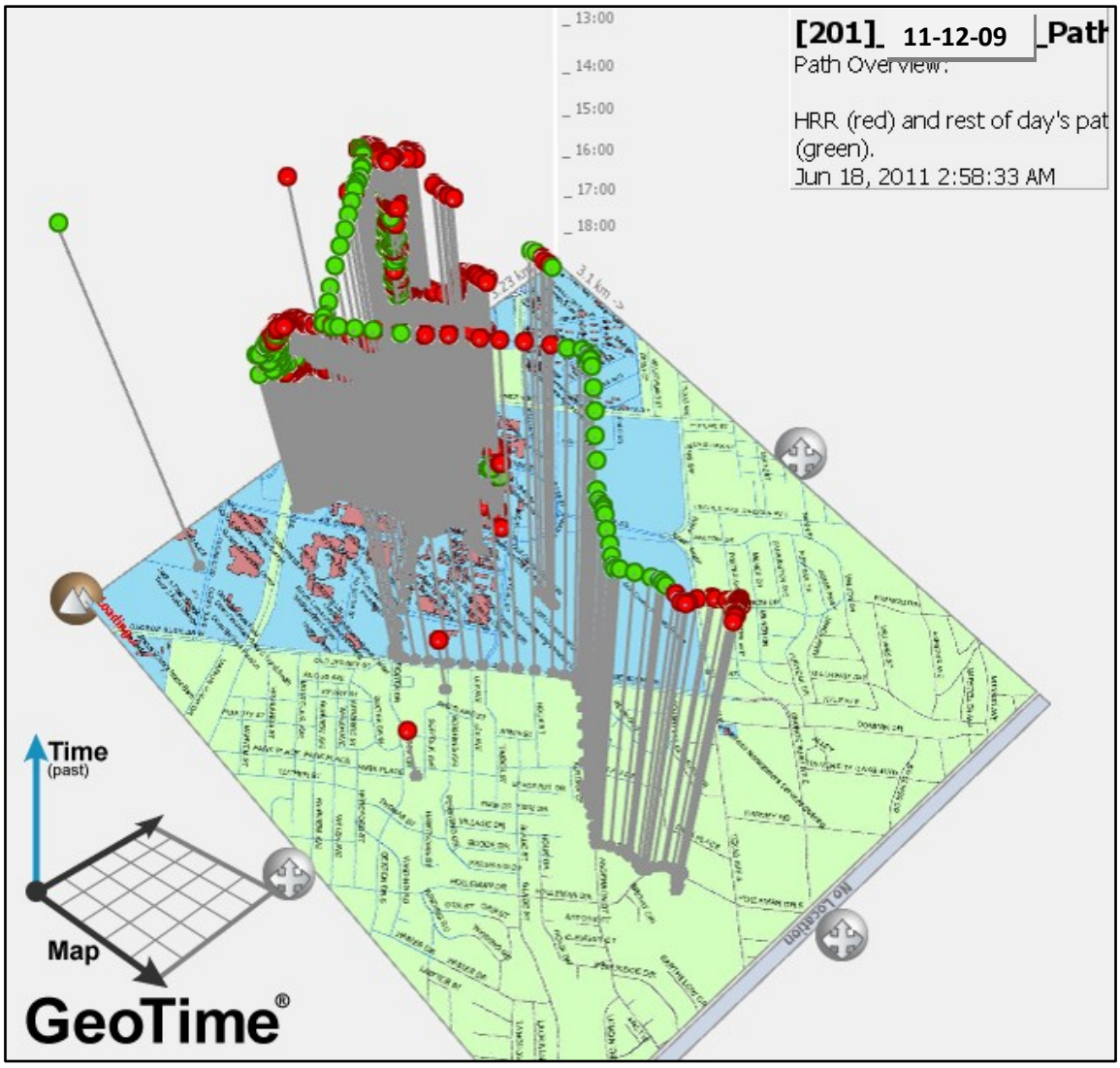



**Figure 15.** Participant 201: map of 11/12/09 daily path.
Note: HRR events are marked in red.

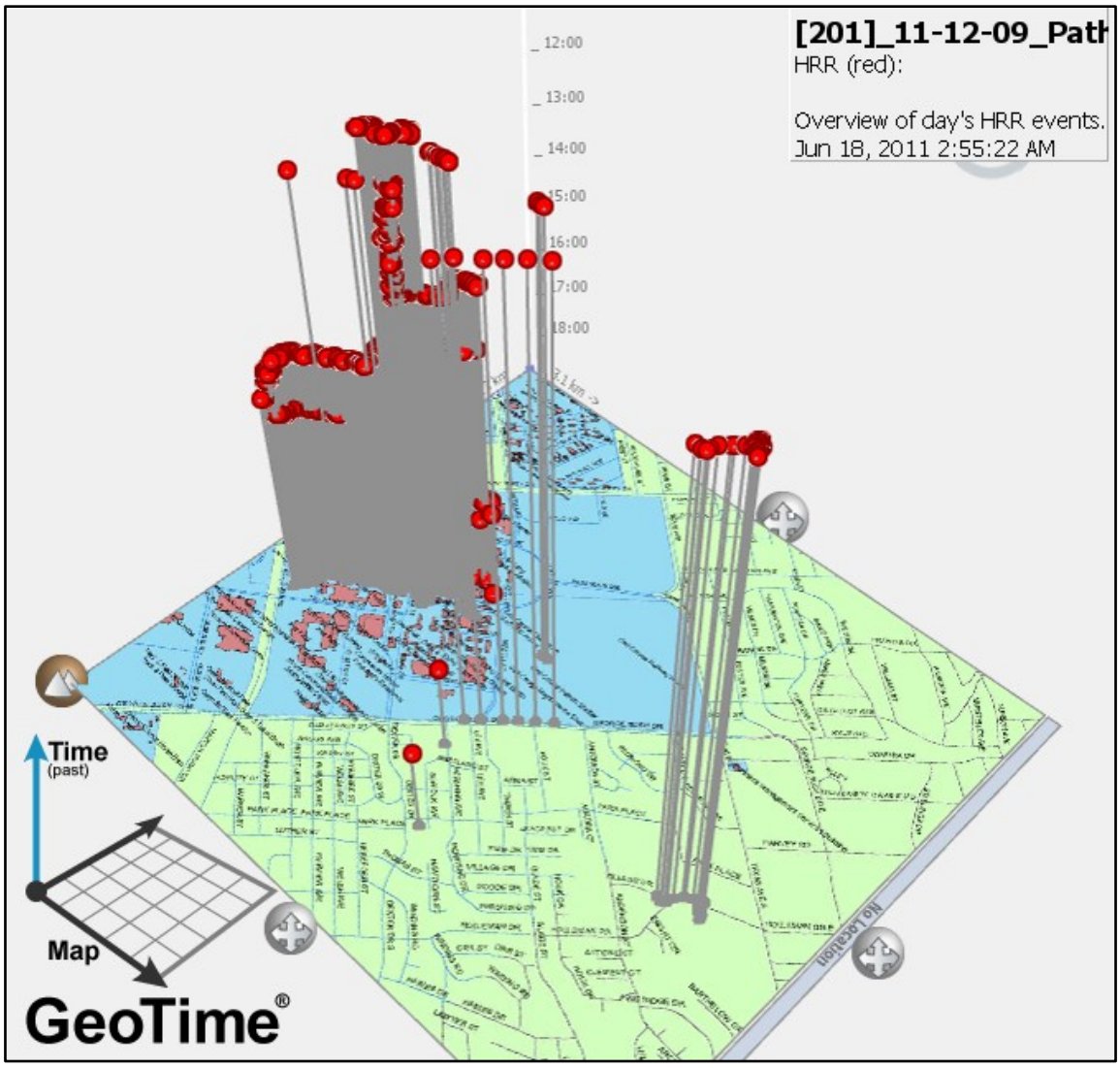



**Figure 16.** Participant 201: map of 11/12/09 logged HRR events.

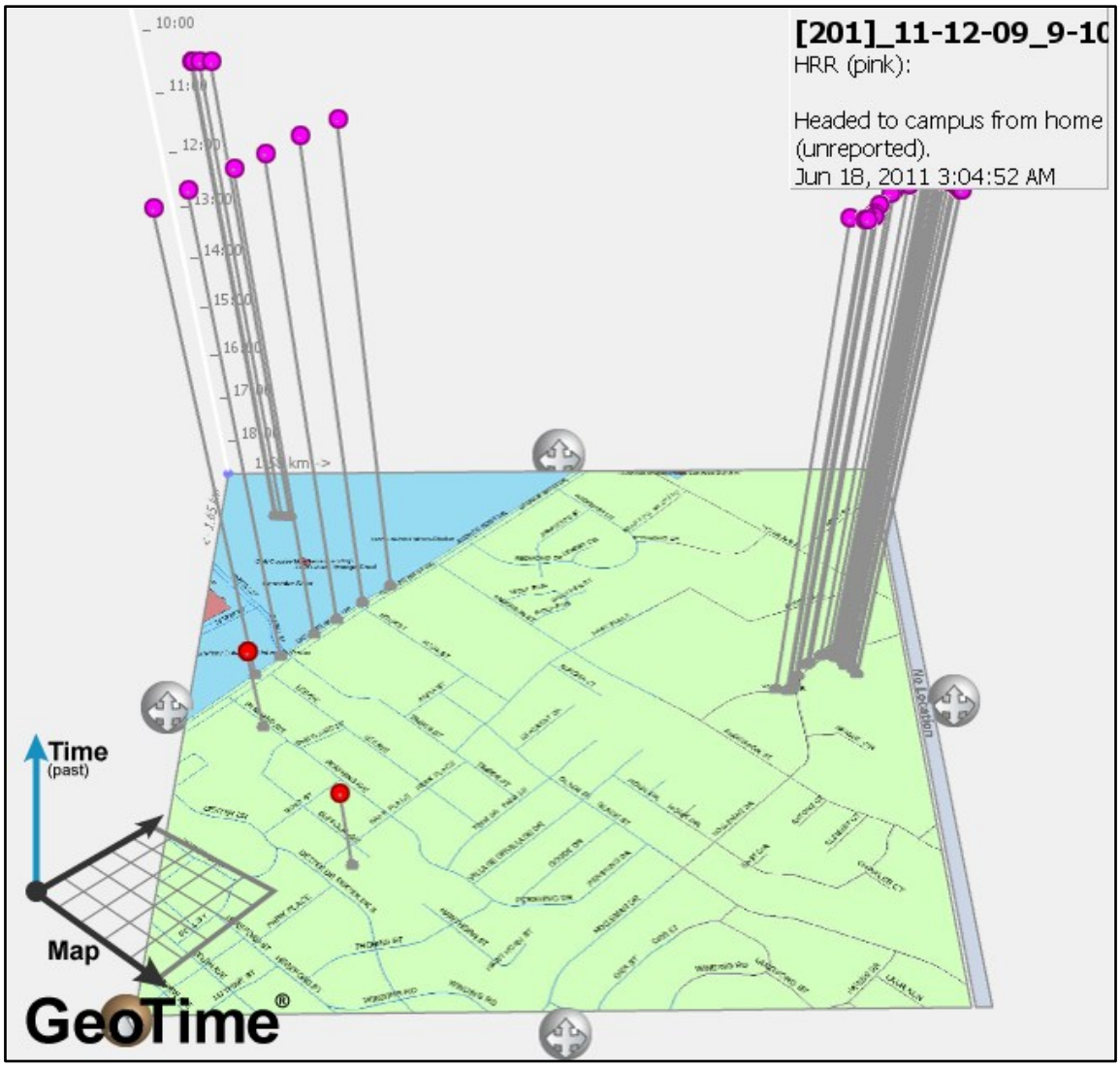



**Figure 17.** Participant 201: map of HRR events (9:00–10:00).
Note: HRR event is in pink and show the participant at home and headed to the bus stop.

In her audio diary the participant talks about Heldenfels as a place, not a mere location. Cognitively she relates Heldenfels with her Biology course and the academic pressures (authoritative constraint) related to exams, labs, and other components of the class. *"And um just to Heldenfels* (Figure 18). *And study a little bit and do the test. And*

*like I said I'm stressed out a lot. And um I think that's what you, Nikki, were talking about when a location becomes a place. To me Heldenfels it's a place, it's taking um it's not a location anymore, it's not just a point on a map, it's a place. Um it's the place where I'll be taking my test and so it's taken a little bit more meaning that building. You know it's oh my gosh the building that I have to go in to take a biology test"* (Entry 4: 11/12/09 @ 9:08). Based on her audio entry and corresponding HR data, the discomfort experienced during the exam was marked (Figure 19). "…*and um mainly the test, you know, toward the end of it I just kind of wanted to get out of that place. Um as soon as the test was over I kind of ran as far as I could out of that place. So um yeah it was pretty stressful but um I would say that the place like I said again once again Heldenfels that was just like like I really wanted to get out of that place as soon as I finished the test* (Figure 20) *I was just kind of like uh need to get out need to get out as far as I can and as fast as I can"* (Entry 5: 11/13/09 @ 12:30). From the beginning of the GPS monitoring the participant's heart rate is elevated. Starting at 9:26 to 9:38 the participant has four HRR events, three lasting several minutes.

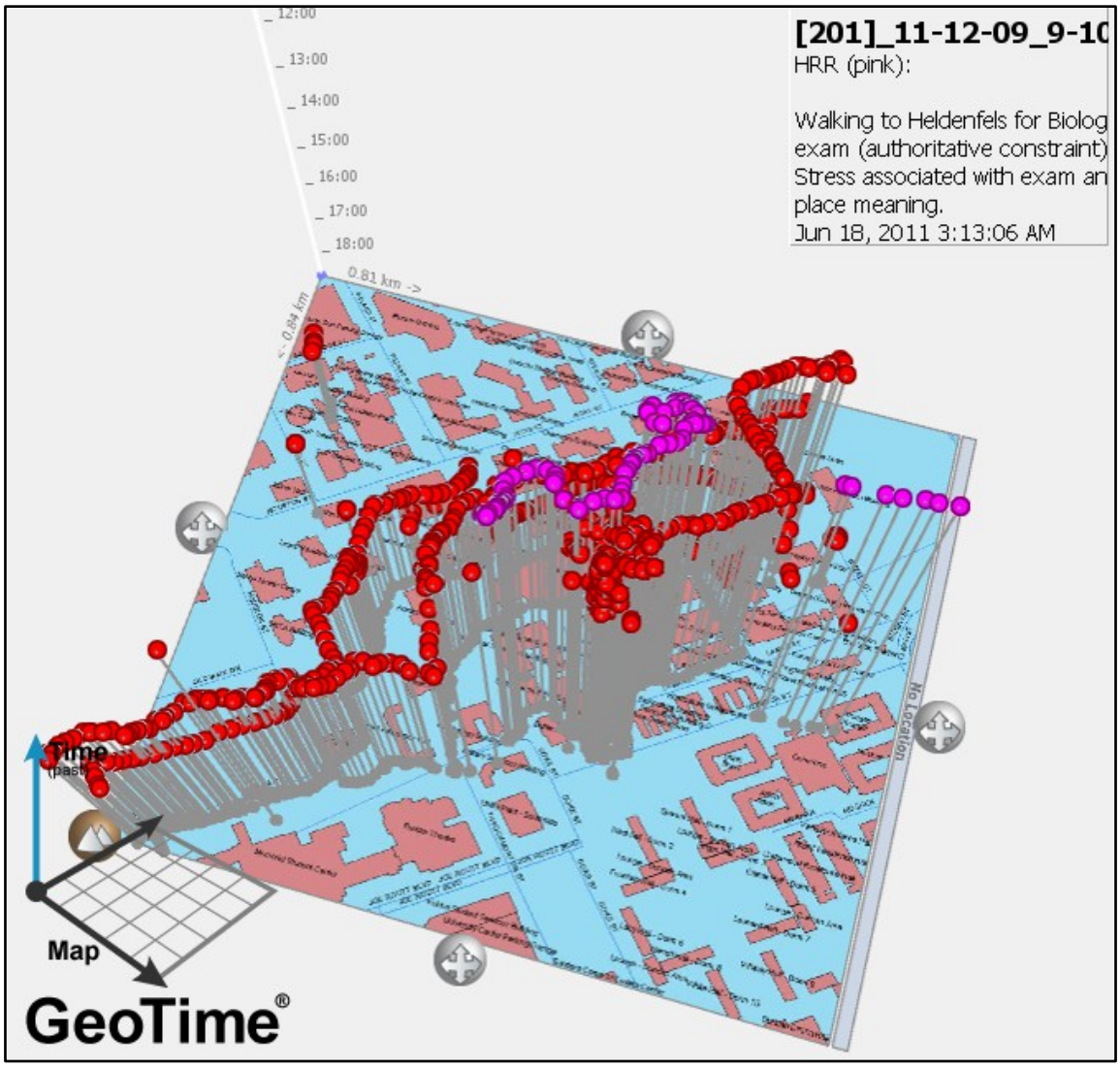



**Figure 18.** Participant 201: map of HR elevation (9:00–10:00).
Note: HRR events are in pink and show elevated HR at the beginning of the Biology exam.

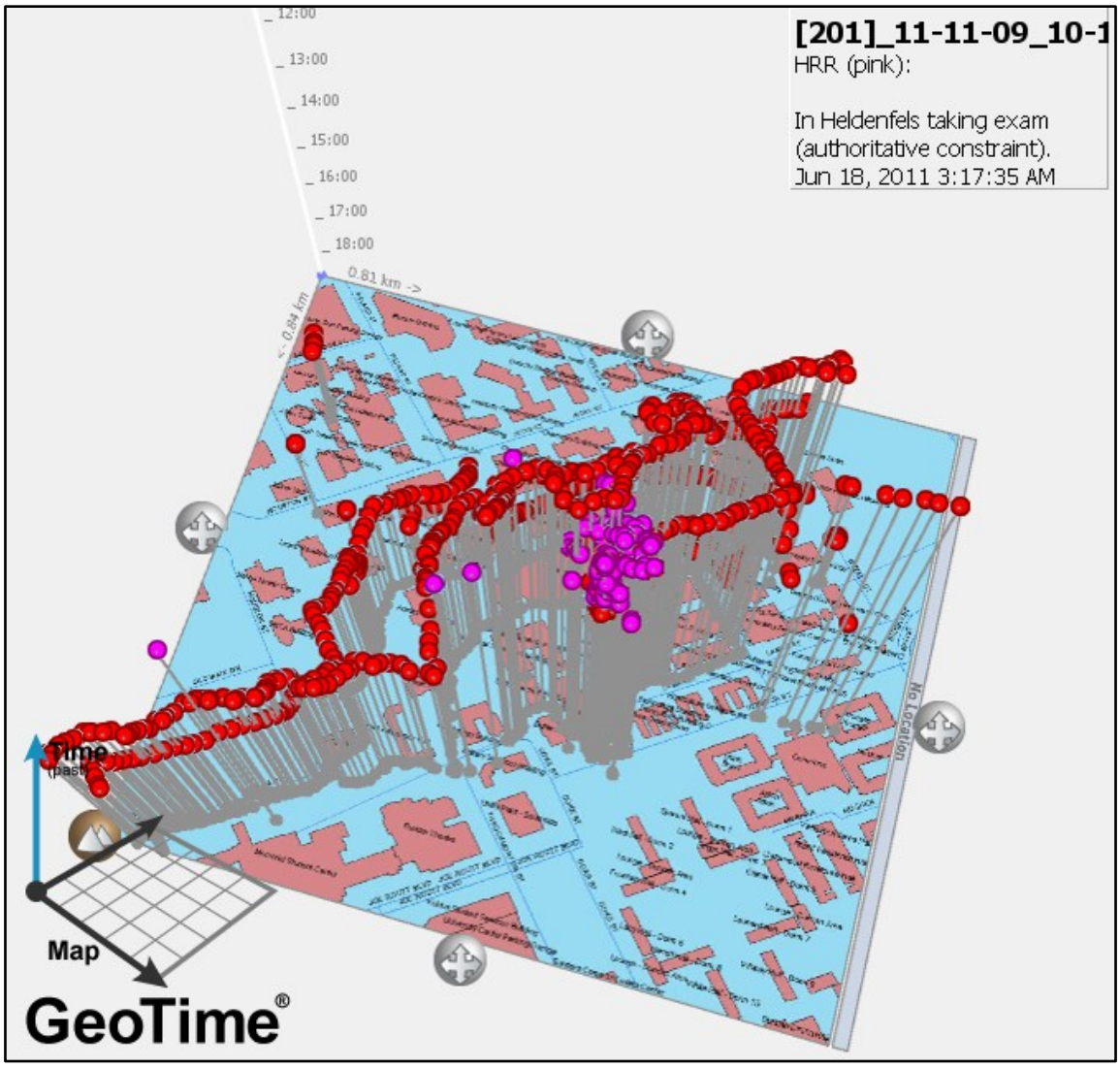



**Figure 19.** Participant 201: map of HRR events (10:00–12:00).
Note: HRR events are in pink and show the participant's HR elevation during the Biology exam.

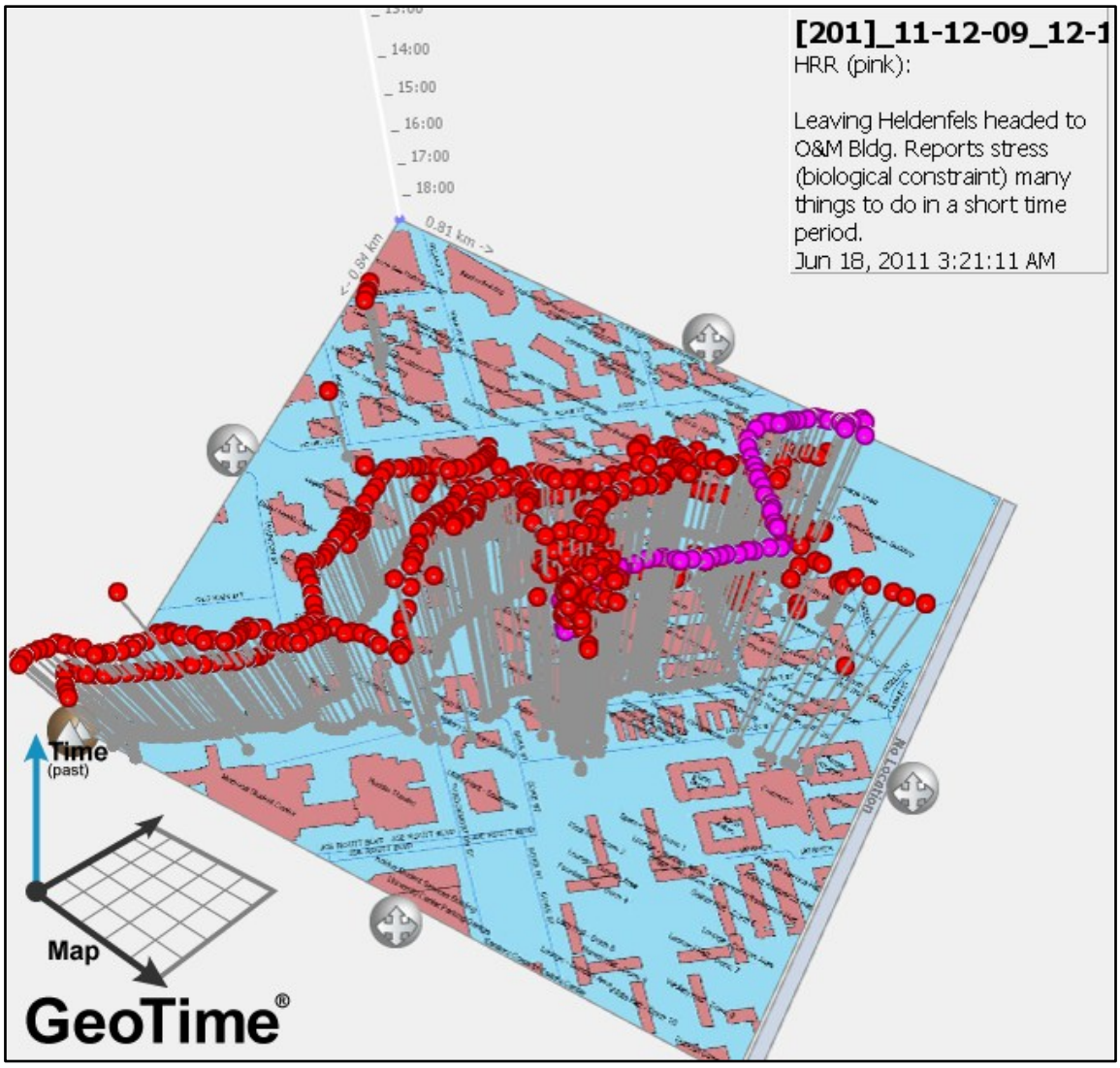



**Figure 20.** Participant 201: map of HRR events (12:00–13:00).
Note: HRR events are in pink and show the participant walking from Heldenfels, after the exam, to the O&M Building to take care of some tasks.

As the second monitoring session comes to an end the participant is experiencing stress for similar reasons as the HRR events at the end of her first monitoring session. She has many tasks to accomplish in a short period of time (biological constraint). *"The*

*end of the second test period went pretty stressful. It was a pretty stressful day; I had a lot going on. So I was running around trying to get everything done… So um yeah but it was a very stressful day um and I headed over to the O&M building* (Figure 21). *And again stressing out a lot because I had to print some things, get to an appointment. So I was very kind of rushed and just like stressing trying to get everything done as soon as I could so…yeah. I mean towards the end of the night towards maybe like the last hour, hour and a half of the um of the testing period everything was well because I had you know was done with like tests, I was done with meetings, and I was done with classes and everything"* (Entry 5: 11/13/09 @ 12:30). Her audio diary discussion reveals an ongoing strategy used to reduce or manage the stress that she is feeling. "*And there were times that I would come down and then I'd freak out again so come down and freaked out again come down freaked out again. So like I kept telling to myself it's okay, it's gonna be okay just calm down. So and then I would freak out again"* (Entry 5: 11/13/09 @ 12:30).

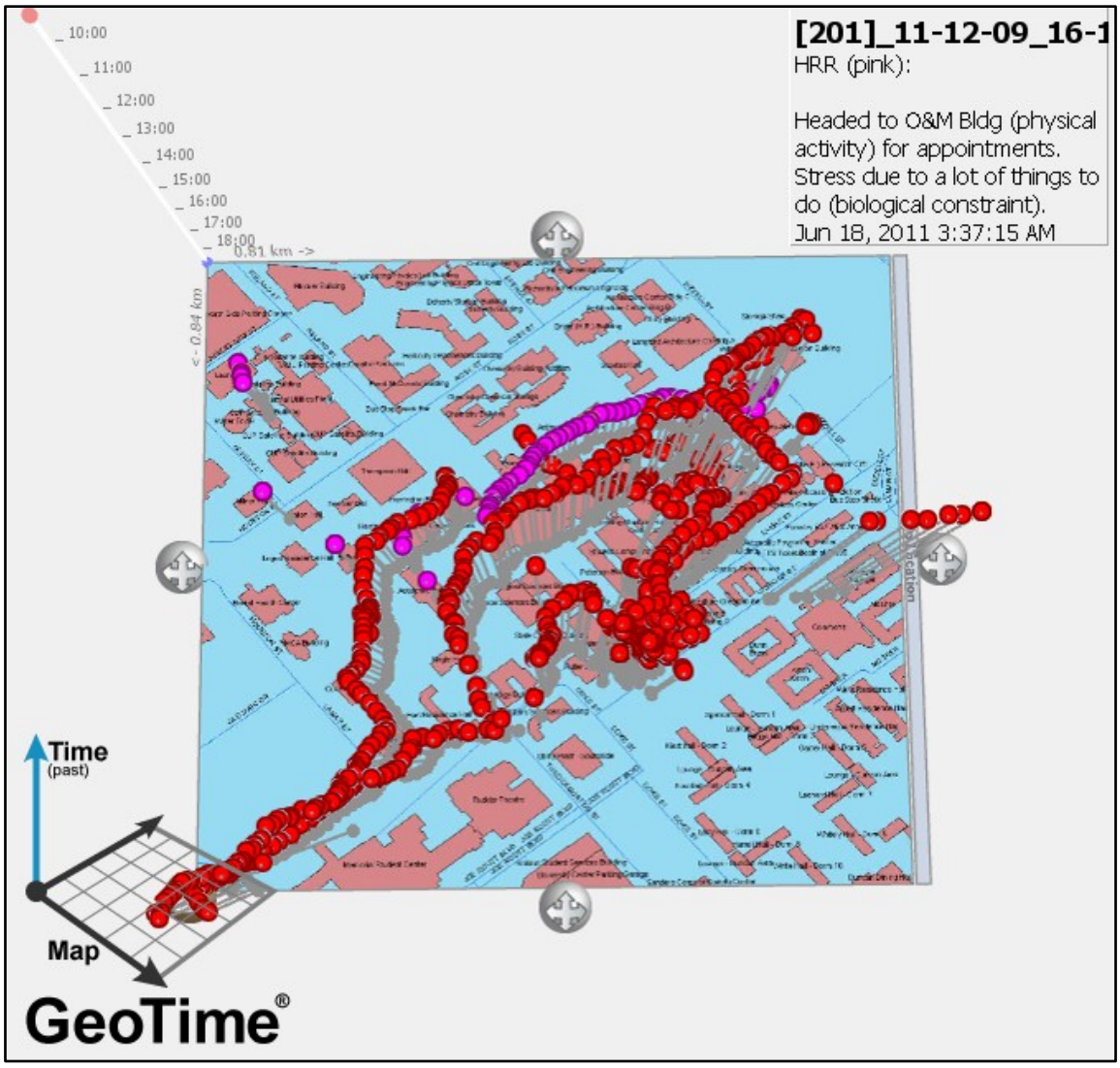



**Figure 21.** Participant 201: map of HRR events ending at (16:00–17:00).
Note: HRR events are in pink and show the participant headed toward the O&M building to take care of several tasks and stating that the pressure felt is related to perceived lack of time.

***Participant 202***

The participant noted only a few conscious stress exposures during the three monitoring sessions. *"So I'm running late for an 8 AM class"* (Entry 1: 11/11/09 @ 7:52). The participant experiences three HRR episodes that cease shortly after 8 am when it is presumed that class began. The HRR episodes recorded by the monitor corresponds to the stress felt when late for a class (authoritative constraint) and the physical activity (walking) required to get to class.

Additionally, through her diary accounts the participant acknowledges that she is generally aware of the average HR displayed by the GPS/HR monitor screen and attributes an observed anomaly to being ill. *"So I've noticed my um heart rate…pressure…resting heart rates have been running high like 90s or 80s or 90s and um I don't know why. I think it's because I'm sick. But I just thought I'd report that"* (Entry 2: 11/12/09 @ 14:58). Immediately before making this entry the participant experiences four HRR episodes, the longest lasting 10 minutes. It's unclear if she is upset or anxious about being ill or if the illness is having a physiological influence on functions such as beats per minute (bmp), blood pressure (BP), and so forth.

*"Um I think Humane Society at like from like 3 to 4 there was a lot to do. Um there wasn't a lot of stress just a lot of things running around activities well it was kind of stressful. Um cleaning cages and getting beds and filling waters and a lot of that was left to do for us"* (Entry 4: 11/12/09 @ 18:10). During the 90 minutes from 15:00 to 16:30 the participant experienced thirty-four HRR episodes. Many of the events lasted longer than 5 minutes, and although the participant attributes the events to the physical activity

required to complete caretaking tasks at the Humane Society she also states that "it was kind of stressful," interpreted as psychological stress ((Entry 4: 11/12/09 @ 18:10).

During her last monitoring session the following account is the only participant-indicated stress exposure but there are two other GPS-logged episodes that are not discussed (Figures 22 and 23). *"Um I'm running late for my 8 AM class on Friday. [Laughs] and I'm gonna climb about four flights of stairs in about 10 minutes so my heart rate will spike a lot then"* (Entry 5: 11/13/09 @ 7:47). After arriving at class in Heldenfels (Figure 24) she had forty-five very brief (only lasting a few seconds) HRR episodes spanning from 8:17 to 9:54 and one longer episode lasting 8:32–8:35 (3 minutes), 20 minutes after starting the last monitoring session. Later in the day the participant experienced unreported HRR events in the area of the Bush Library (Figure 25) and what is presumed to be her place of residence (Figure 26). The footprint of the monitored path in the area of the Bush Library (Figure 25) is consistent with walking but there are no helpful clues to the nature of the other stressor.

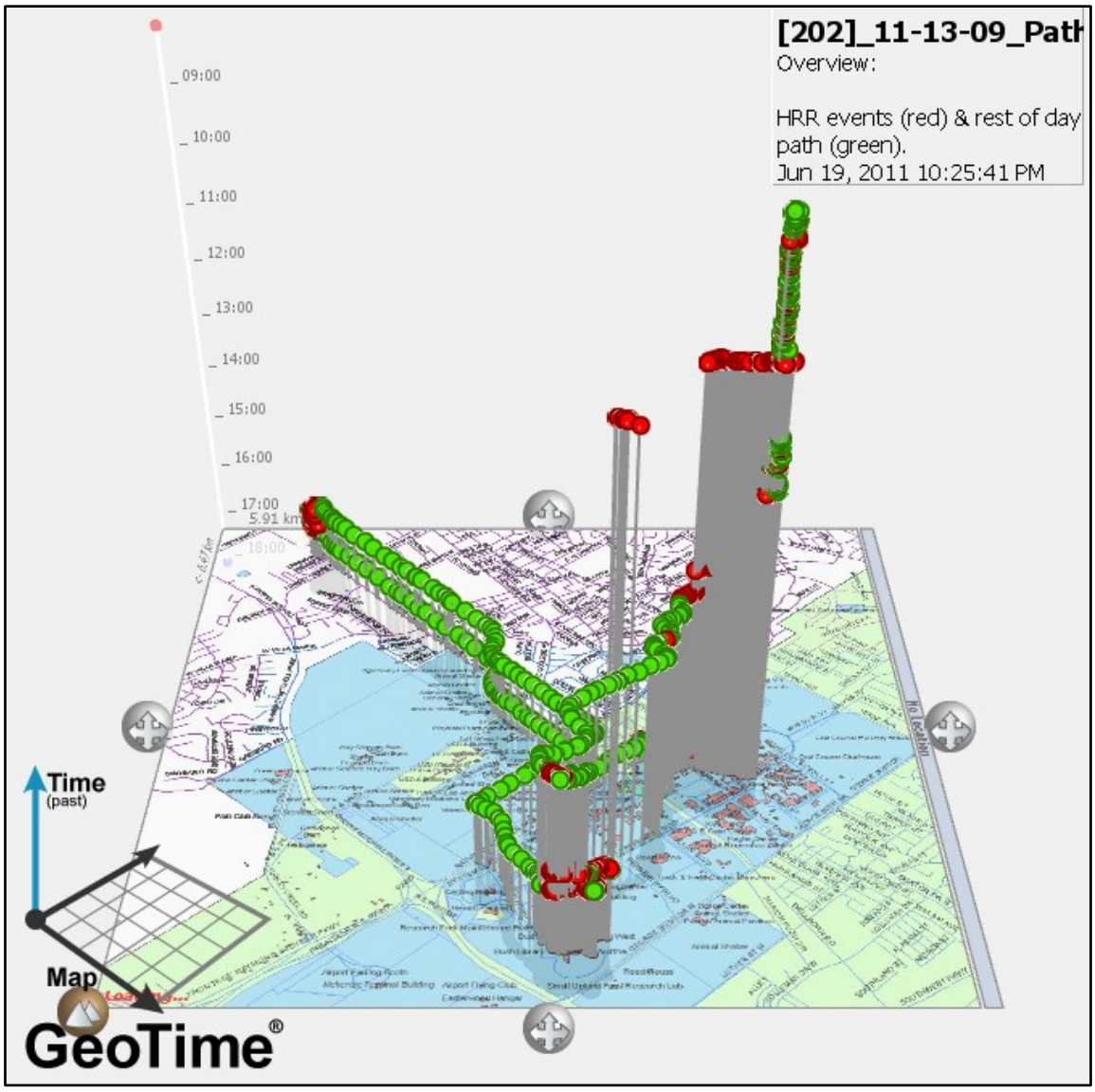



**Figure 22.** Participant 202: map of 11/13/09 daily path.
Note: HRR events are marked in red.

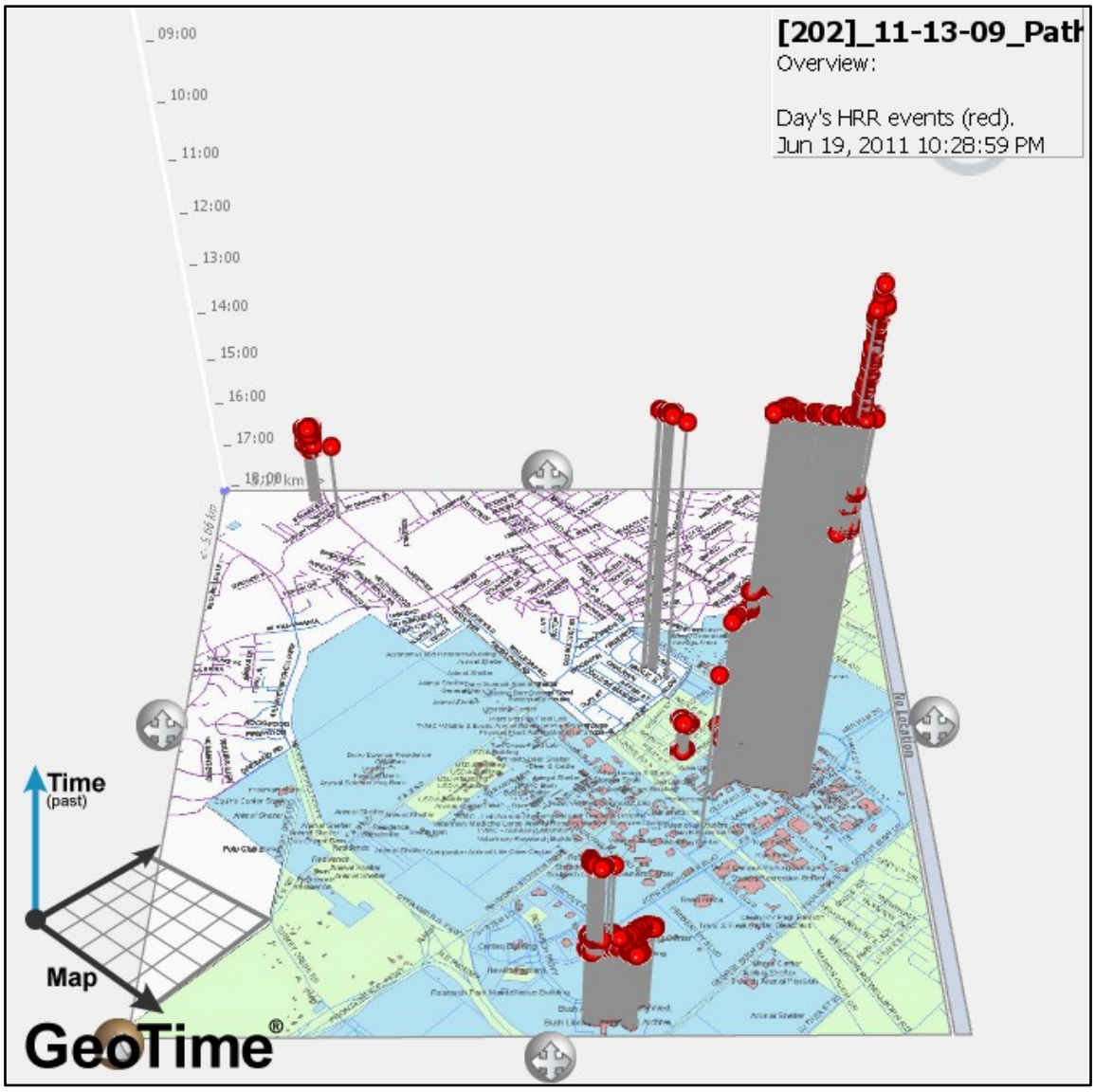



**Figure 23.** Participant 203: map of 11/13/09 logged HRR events.

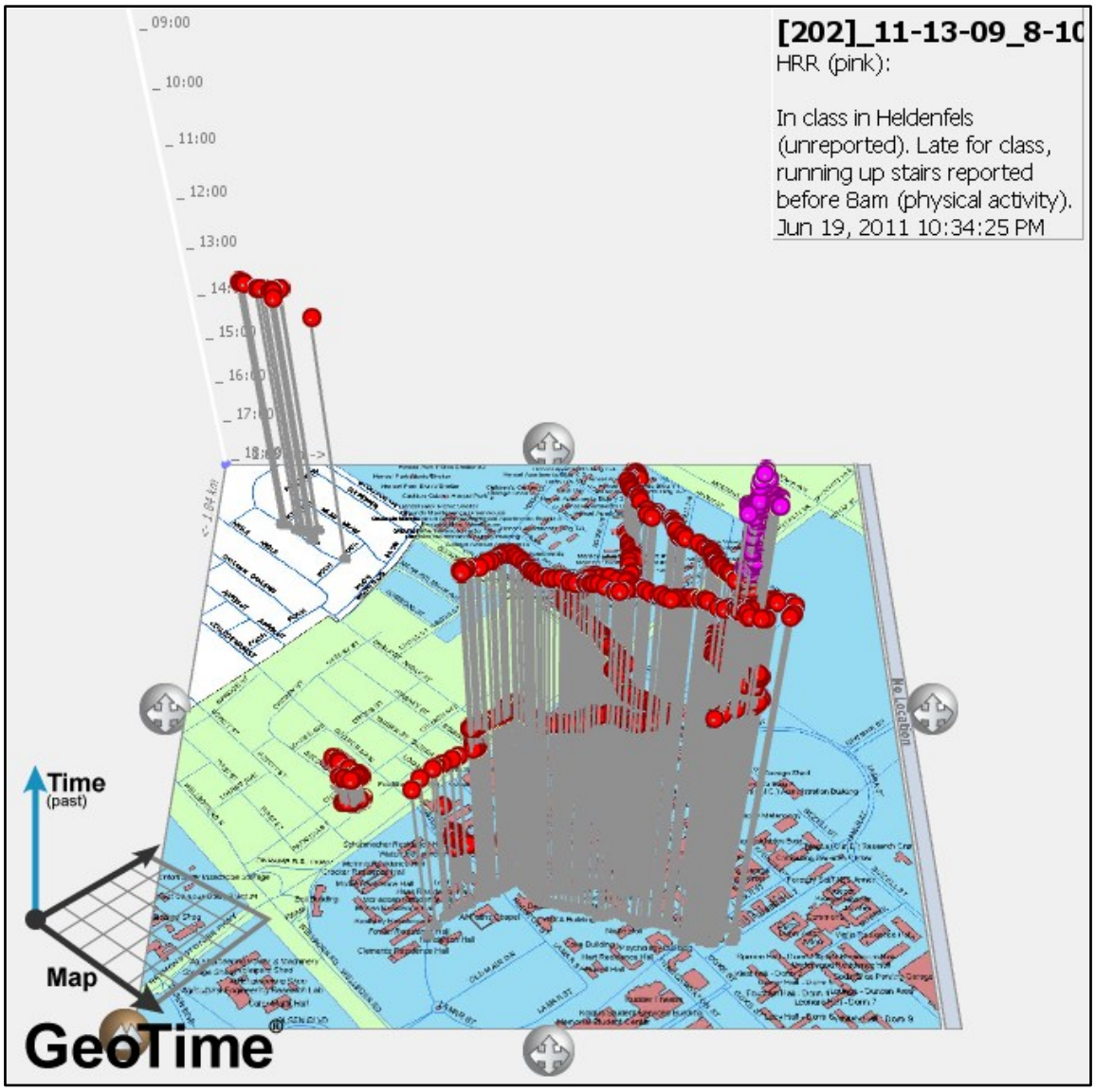



**Figure 24.** Participant 202: map of HRR events (8:00–10:00).
Note: HRR events are in pink and they occurred during the participant's class in Heldenfels.

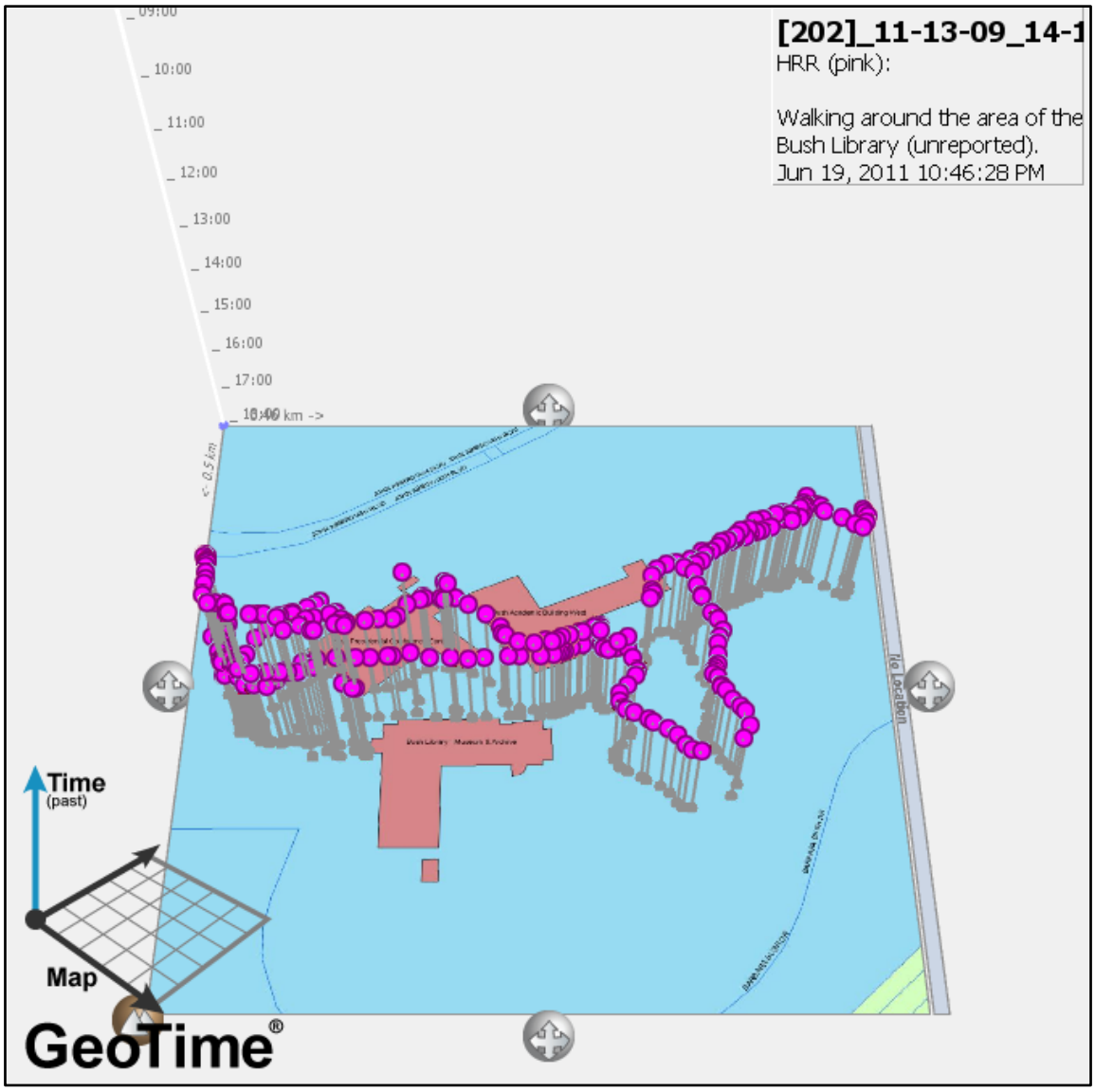



**Figure 25.** Participant 202: map of increased HR (14:00–17:00).
Note: shows the participant's elevated HR while walking around the Bush Library area.

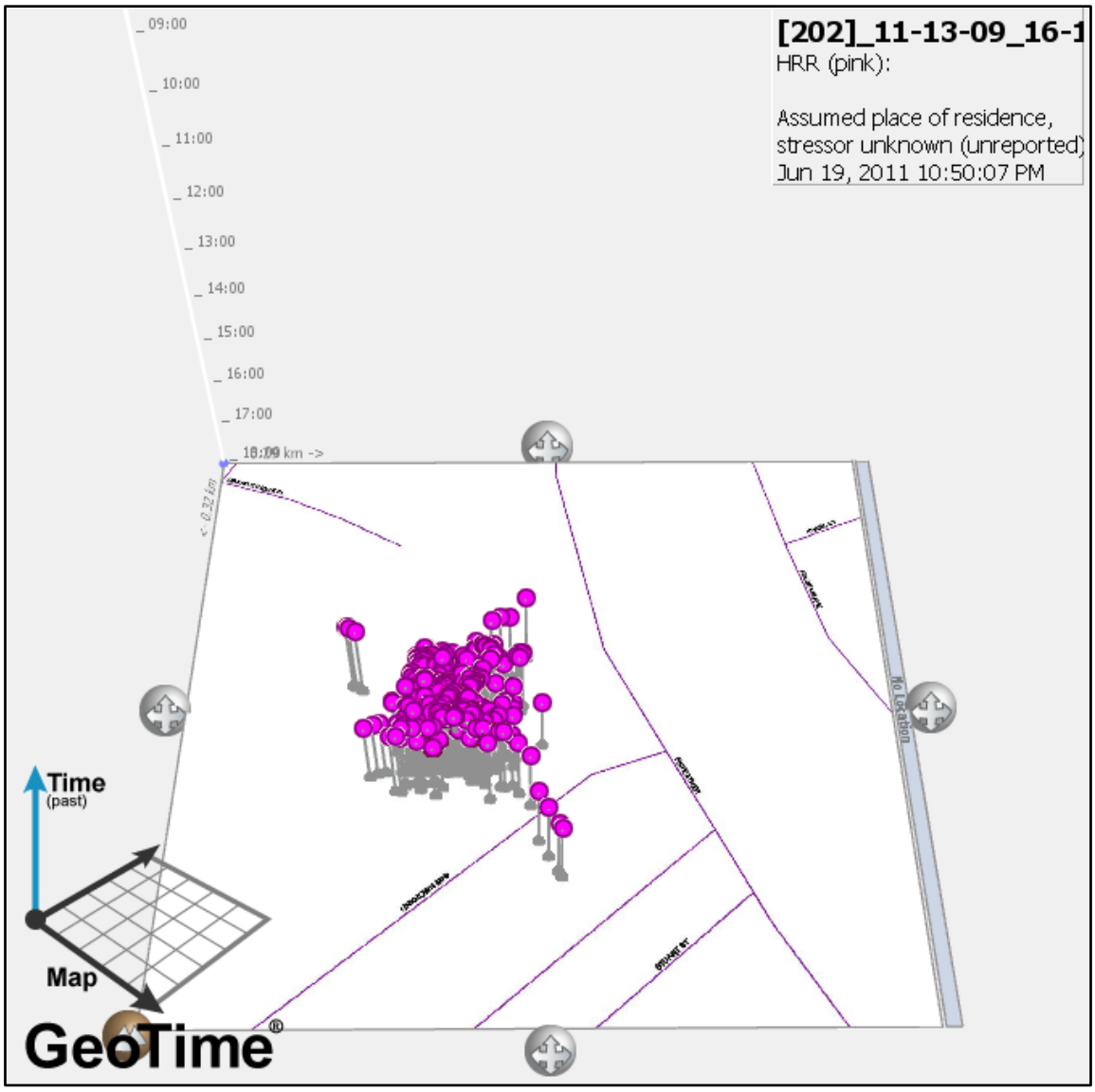



**Figure 26.** Participant 202: map of HRR events (16:00–17:00).
Note: shows HRR events at what is presumed to be the participant's place of residence.

***Participant 203***

GPS/HR data were not recorded for this participant. The only data collected are audio diary entries (Appendix H).

***Participant 204***

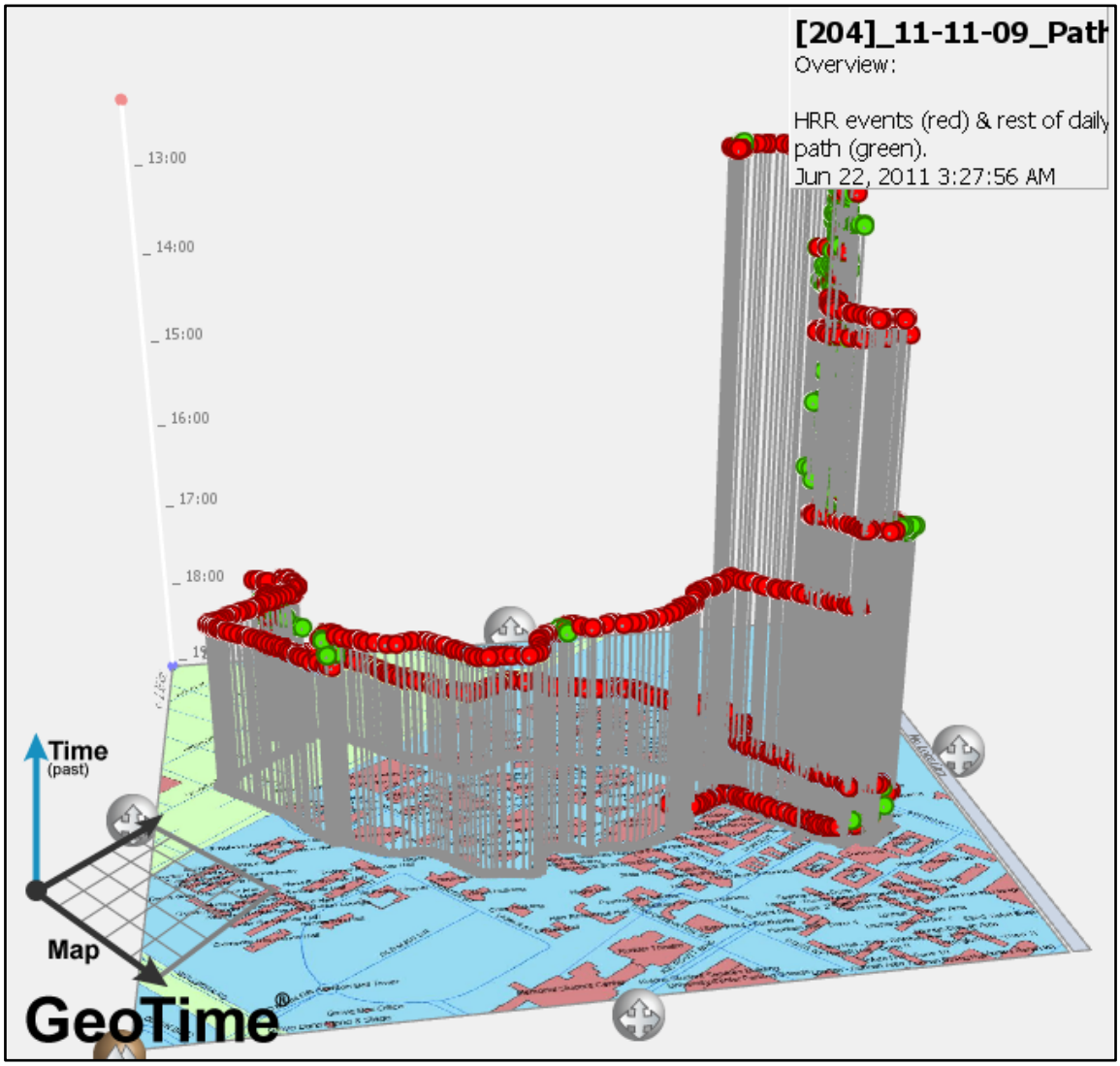



**Figure 27.** Participant 204: map of 11/11/09 daily path.
Note: HRR events are marked in red.

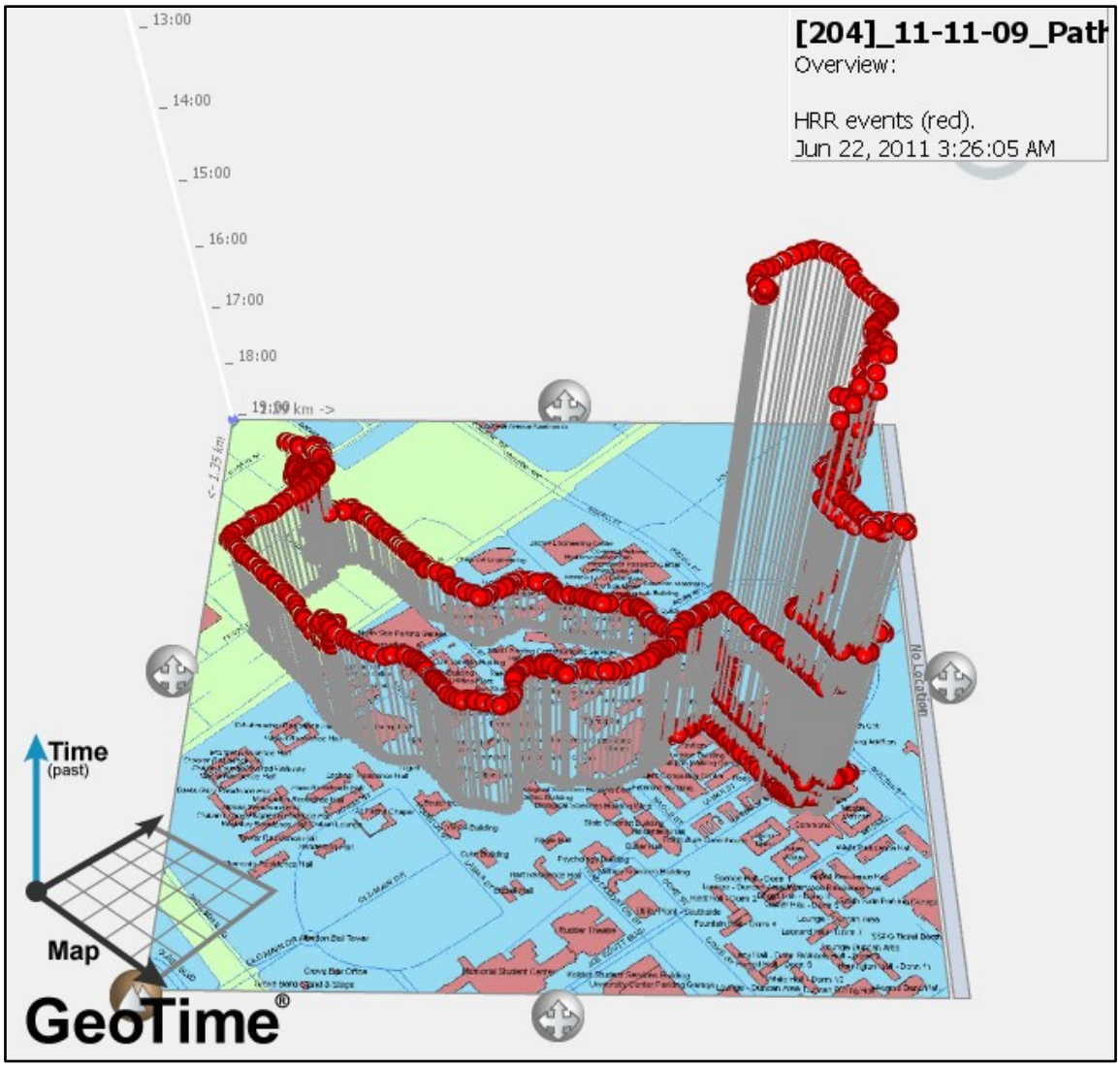



**Figure 28.** Participant 204: map of 11/11/09 logged HRR events.

After looking through all of this participant's data, the author determined that the timestamp on the audio diary entries is an hour ahead of the actual time. The discrepancies are verified by the entries in which he states the time and the spatial data that corroborates given audio diary information. Much of the GPS/HR monitor-logged HRR events for this participant are clearly in transit, walking from one location on

campus to another (Figures 27 and 28). He did experience some HRR episodes related to class times and time spent working on assignments but also of interest are times when this participant uses his audio diary to reflect on stress. As with the example that follows, he asserts the belief that he is not likely to experience stress in a particular place or situation. *"So now I'm about to go into my Spanish class. I guess only stressful thing that is going on there is I have a quiz. But I mean Spanish is pretty easy to me so I don't think I'll be freaking out about it"* (Entry 3: 11/11/09 @ 12:13). From 11:08–11:15 (7 minutes) he experienced an HRR event, which could be related to the quiz (authoritative constraint) or walking to class (physical activity). Over the next hour, while in Spanish class, the participant has forty-six brief HRR episodes.

*"Um I don't know the more I keep thinking about this stress thing the more I don't feel stressed. I don't know maybe I'll feel stressed whenever I'm writing my paper and doing homework. I don't know"* (Entry 4: 11/11/09 @ 13:24). The above statement was recorded about 15 minutes before the student's Geography class started. From 12:27–12:36 (9 minutes) he experiences a sustained HRR event that corresponds to walking to class (Figure 29). During the class period the majority of his thirty-nine HRR episodes are brief, with only four lasting longer than a minute (Figure 30). The participant does experience HRR events contrary to his given reflections regarding the lack of stress but the events of significant duration are associated with physical activity.

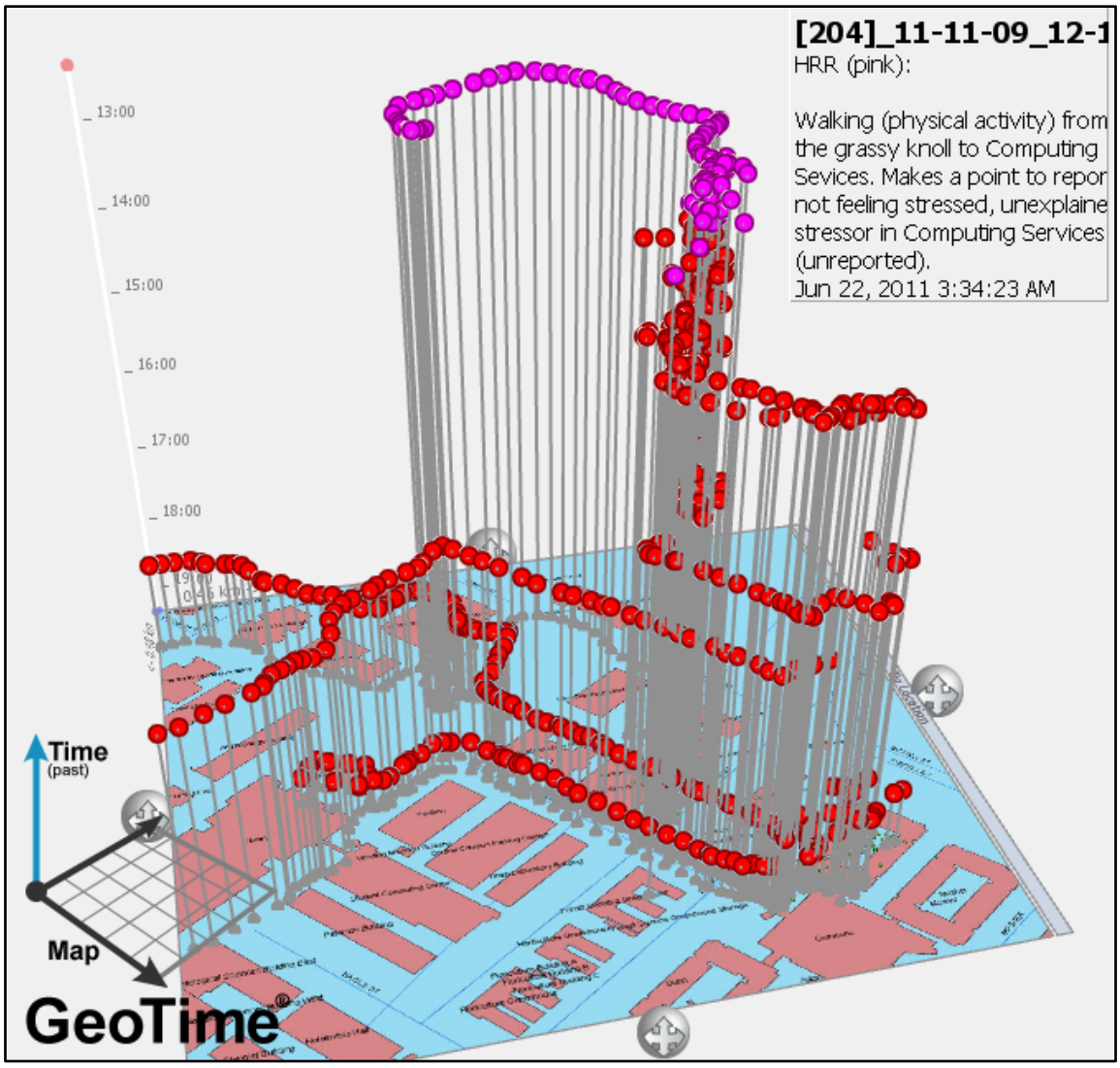



**Figure 29.** Participant 204: map of HRR events (12:00–13:00).
Note: HRRs event are in pink and show the participant walking from the grassy knoll to the Computing Services (CS) before Geography class.

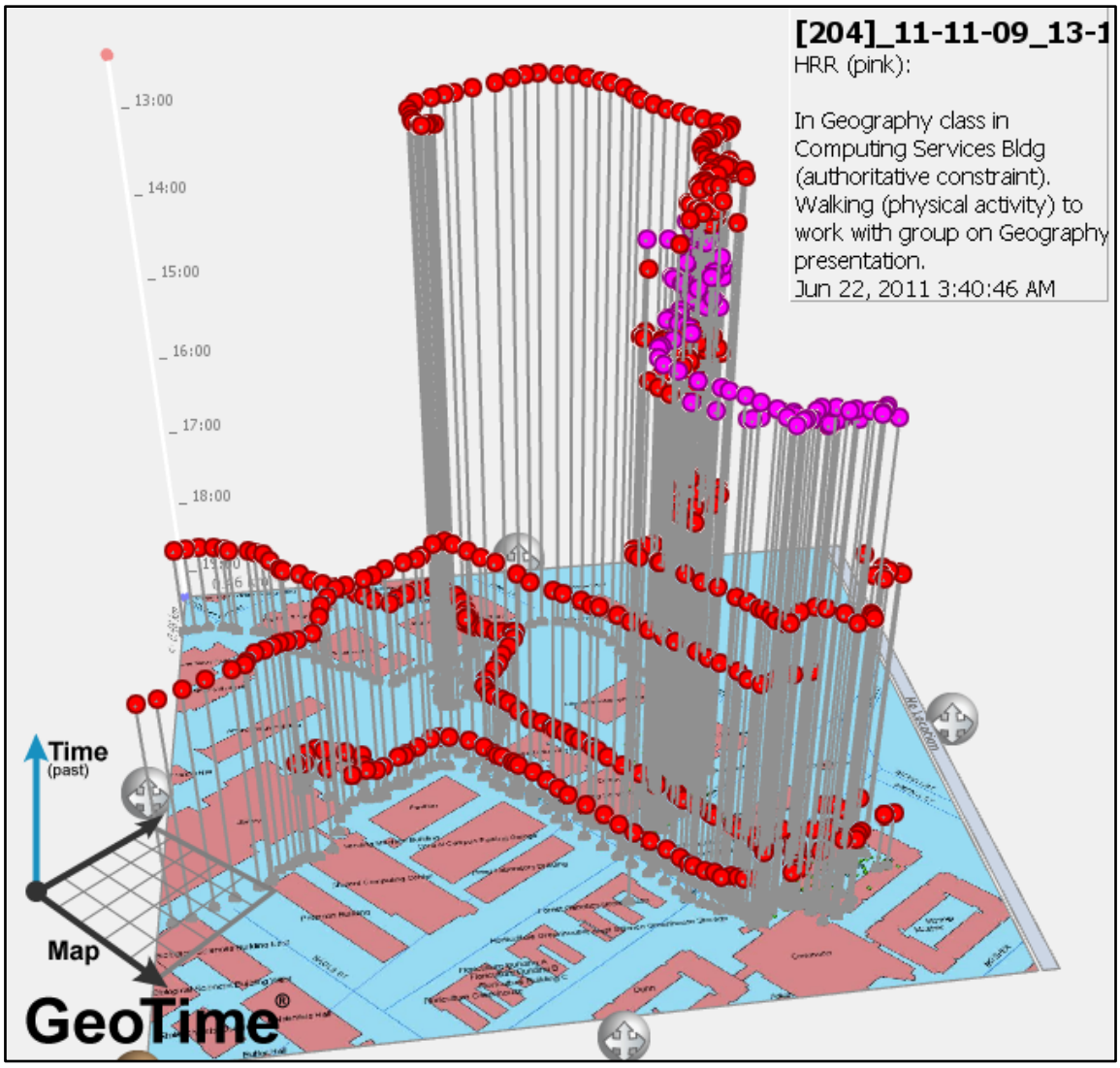



**Figure 30.** Participant 204: map of HRR events (13:00–14:00).
Note: HRR events are in pink and show the participant in CSA, which is an annex of the Computing Services Building.

After class he went to work on a group project (Figure 31). *"…uh I have there is six people in my group and we all work together pretty well. We don't really fight a lot or anything and there's not really any authoritative figures. We just uh work together pretty*

*well so I don't think it's gonna be very stressful. We're just going to be putting together pretty much a PowerPoint presentation and talking about our subject"* (Entry 5: 11/11/09 @ 14:55). During the group work period (Figure 32), which lasts until about 15:50, the participant experiences nineteen HRR events and out of the nineteen, three were longer than a minute.

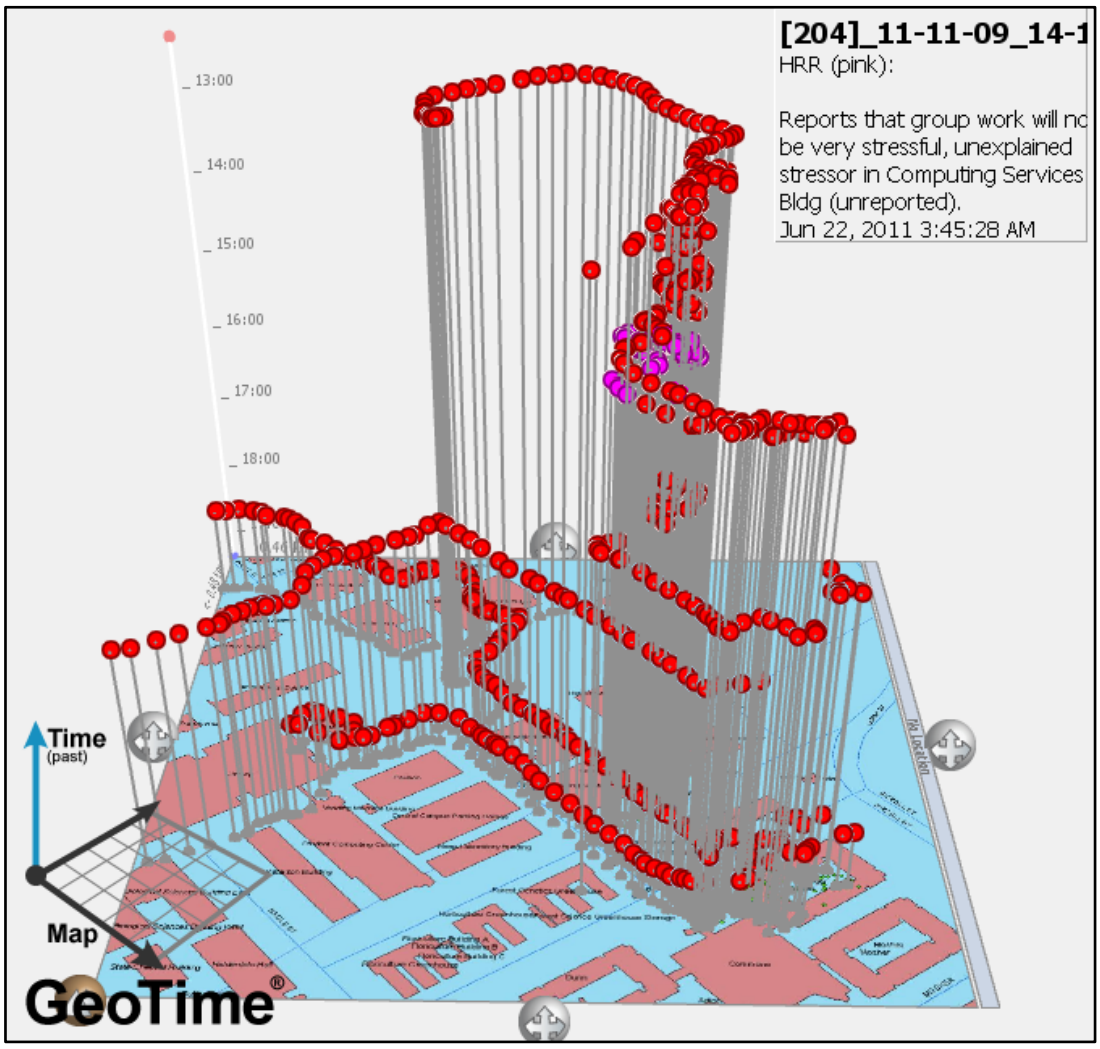



**Figure 31.** Participant 204: map of HRR events (14:00–15:00).
Note: these events are in pink and show unreported HRR events during the time the participant reported that he was working on a group presentation.

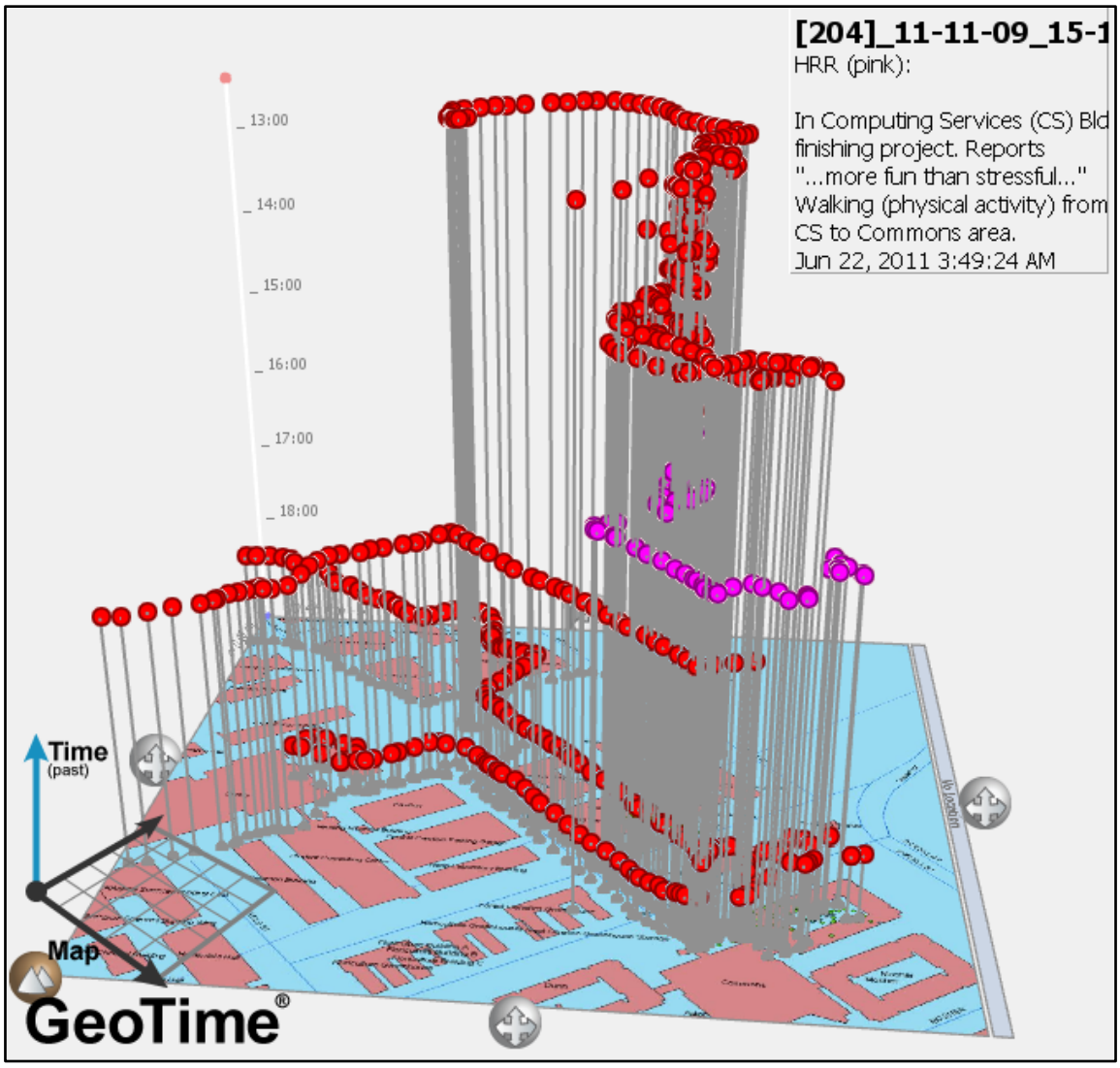



**Figure 32.** Participant 204: map of HRR events (15:00–16:00).
Note: HRR events are in pink and show the participant in Computing Services Building finishing up with group project.

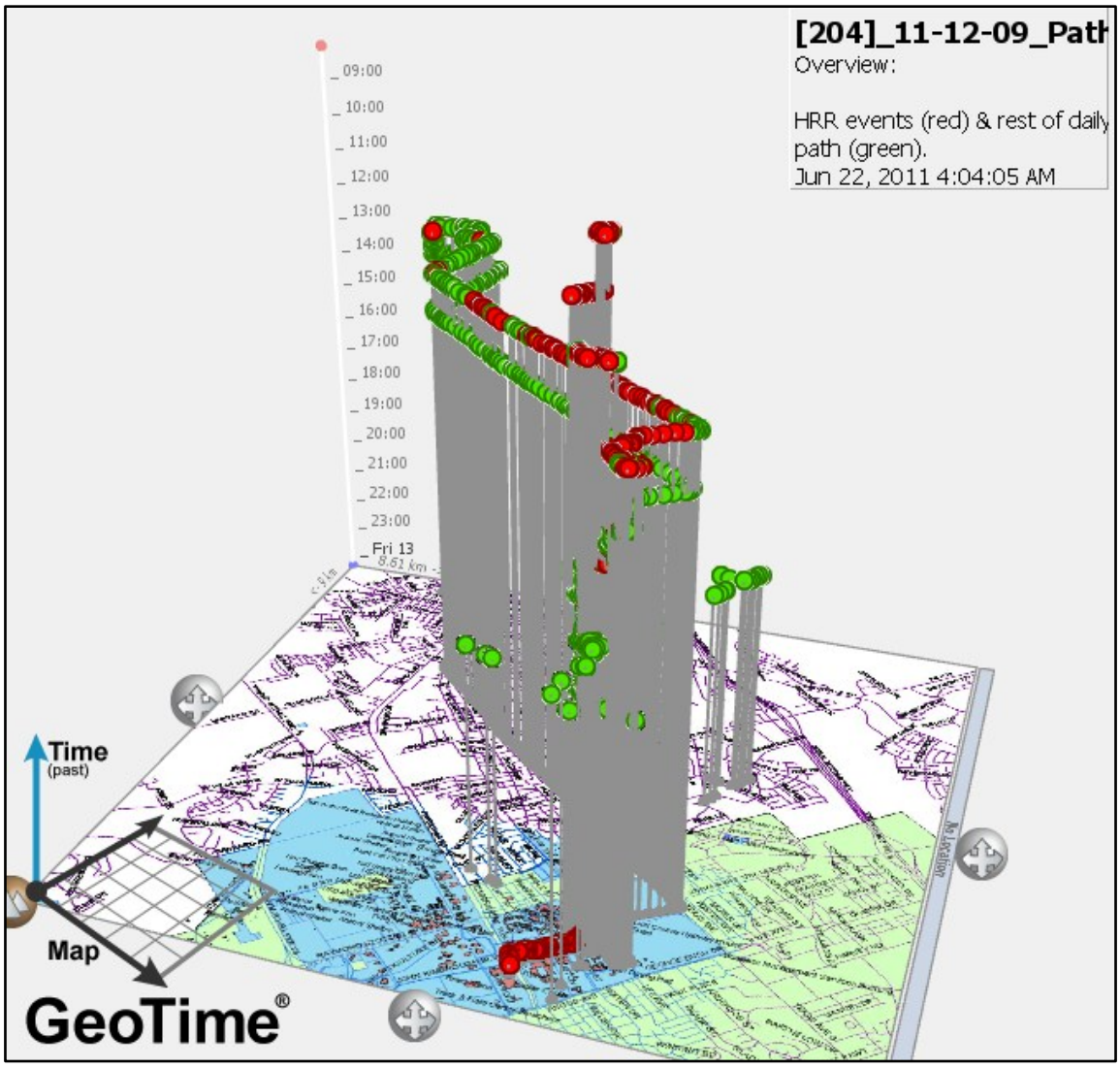



**Figure 33.** Participant 204: map of 11/12/09 logged daily path.
Note: HRR events are marked in red.

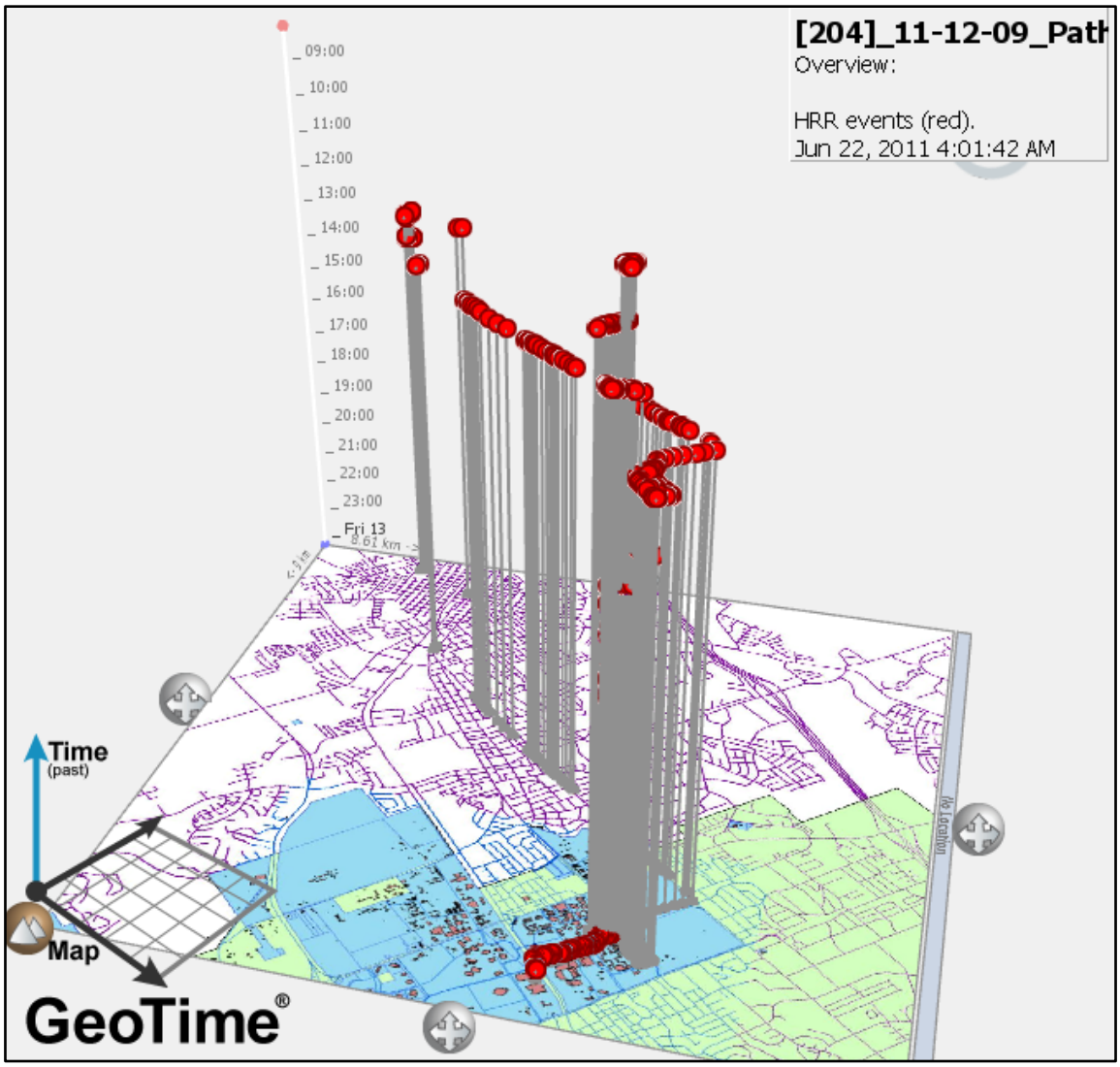



**Figure 34.** Participant 204: map of 11/12/09 logged HRR events.

The second monitoring period starts off with a stressor (Figures 33 and 34). The participant is late for class which, according to him, is a regular occurrence (Figure 35). *"I have GIS class at well it starts at eight but I just kind of had a long night last night. I was writing my paper so um I'm walking to class right now into the O&M Building. So… it's just another Tuesday Thursday because I'm always late for this class anyway. It*

*starts at 8 AM so I'm never on time"* (Entry 7: 11/12/09 @ 9:20). From 8:19–8:23 (4 minutes) there is an HRR event, then his HR goes down until 9:07 when he experiences seven brief HRR episodes leading up to the 9:20 diary entry.

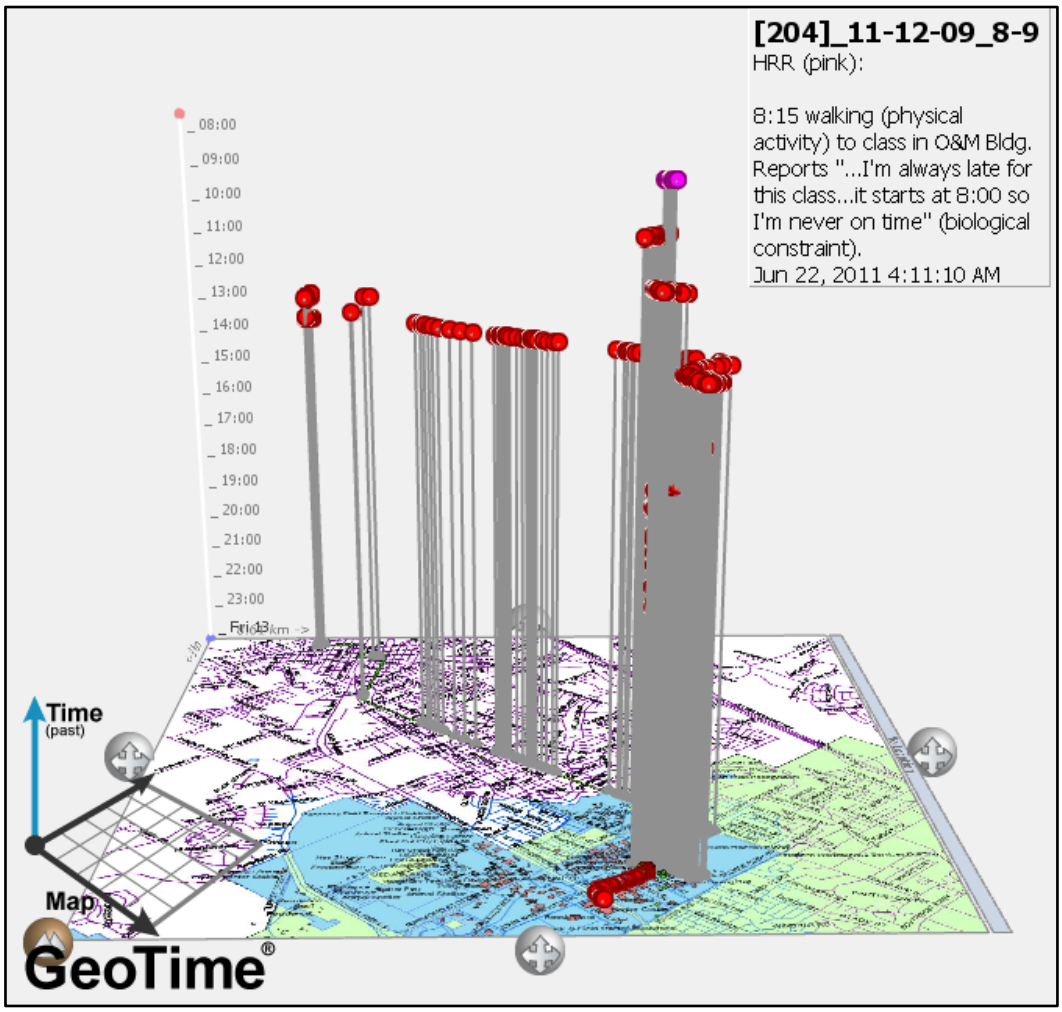



**Figure 35.** Participant 204: map of HRR events (8:00–9:00).
Note: HRR events are in pink and are due to the participant being late for his first class.

The participant experiences fifteen HRR episodes in the 30 minutes prior to arriving at Neil Elementary School to tutor a student (Figure 36). It is clear that these events occur while in transit (driving) but there is no further explanation. "*The time is now 12:50. I am outside of Neil Elementary School in Bryan. I'm going to do my host shift. It's um the thing sort of helping one student to succeed. What I do is I help tutor a second grader in math and reading and just help him kinda like be his mentor I guess or his big brother kinda thing. Um so that's what I'm gonna do for the next 30 minutes. It's not really stressful helping the kid it's more fun than it is anything else because, I mean, you can tell whenever they look up to you and it's a good feeling and just being helping them is great in itself so. It's real rewarding"* (Entry 9: 11/12/09 @ 13:51). Only two HRR events are recorded during the 30-minute tutoring session.

It is later in the day and the participant is now in the Student Computing center working on an essay (Figure 37). *"I am in SCC about to finish writing my essay for Dr. Houser. Have about a page and a half left to go so hopefully I can get it done now so don't worry about it later tonight. ...I don't feel much stress right now so I guess I don't really feel stressed that much or this is just not a very stressful week for me"* (Entry 10: 11/12/09 @ 16:30). During his time working in the SCC, which lasted until around 19:00, there were eleven short HRR episodes.

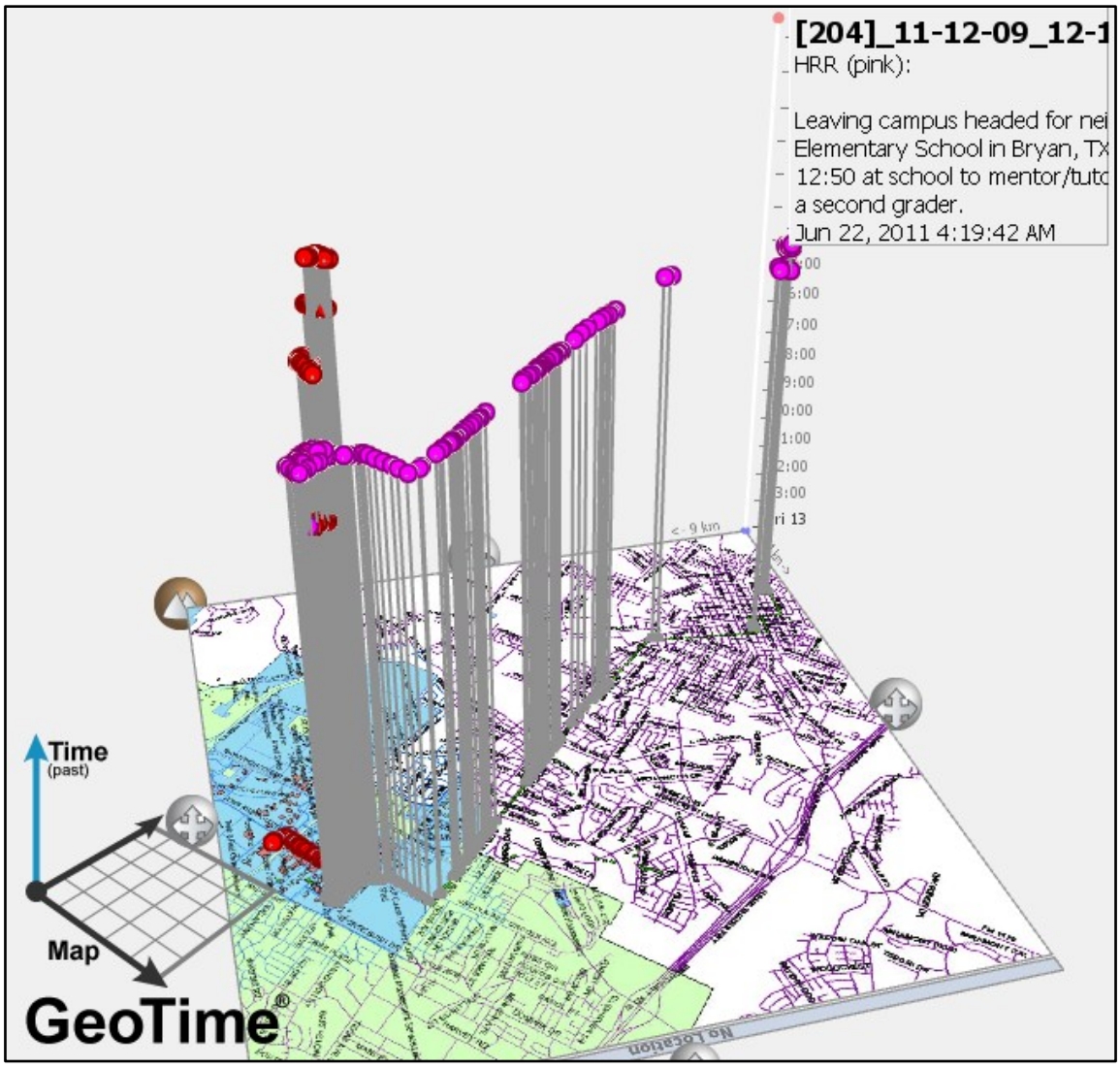



**Figure 36.** Participant 204: map of HRR events (12:00–13:00).
Note: HRR events are in pink and show the participant in transit to tutor a middle school student at Neil Elementary school in Bryan, Texas.

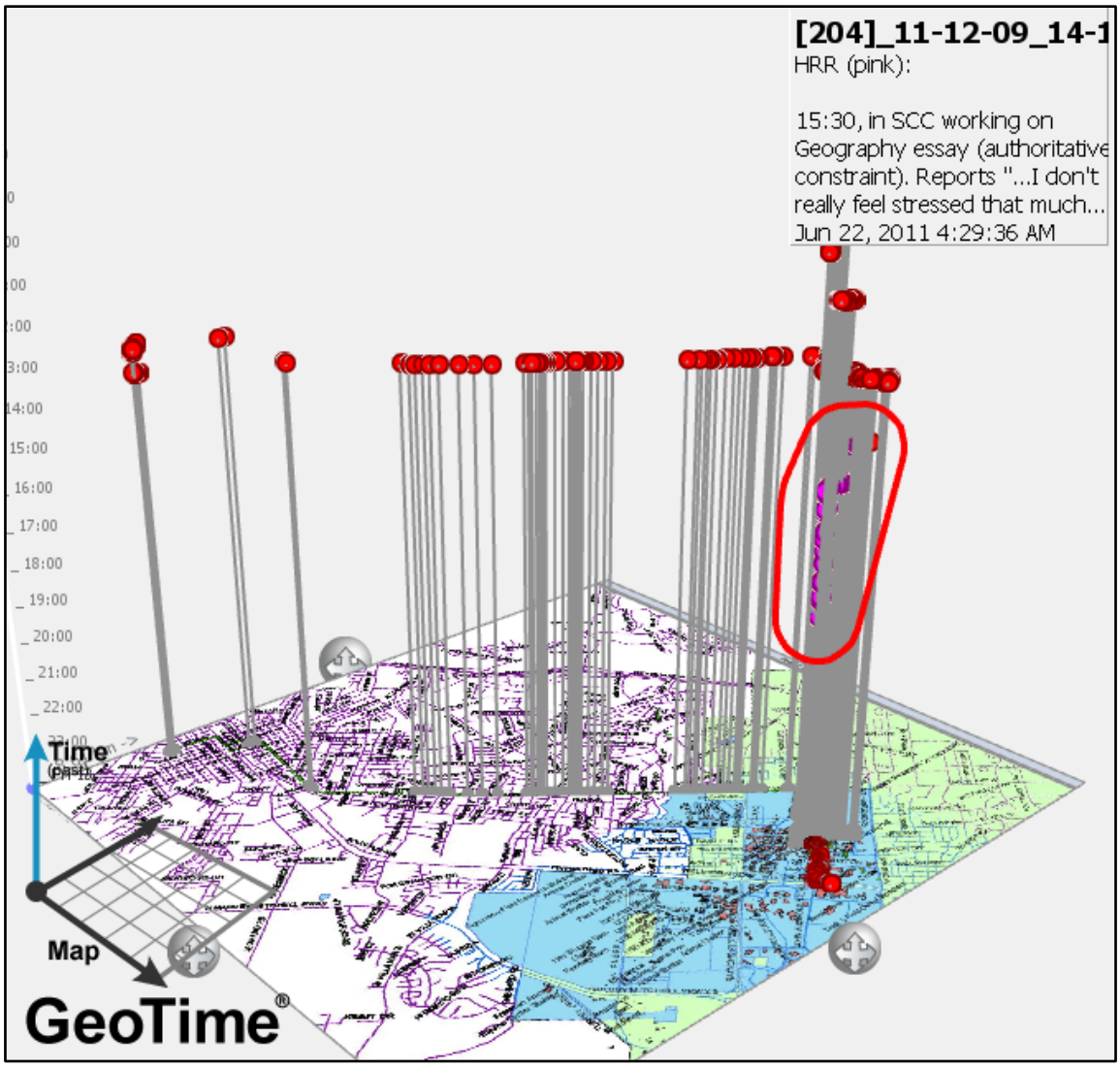



**Figure 37.** Participant 204: map of HRR events (14:00–19:00).
Note: HRR events in pink (circled in red) and show episodes experienced while working on an essay in the SCC.

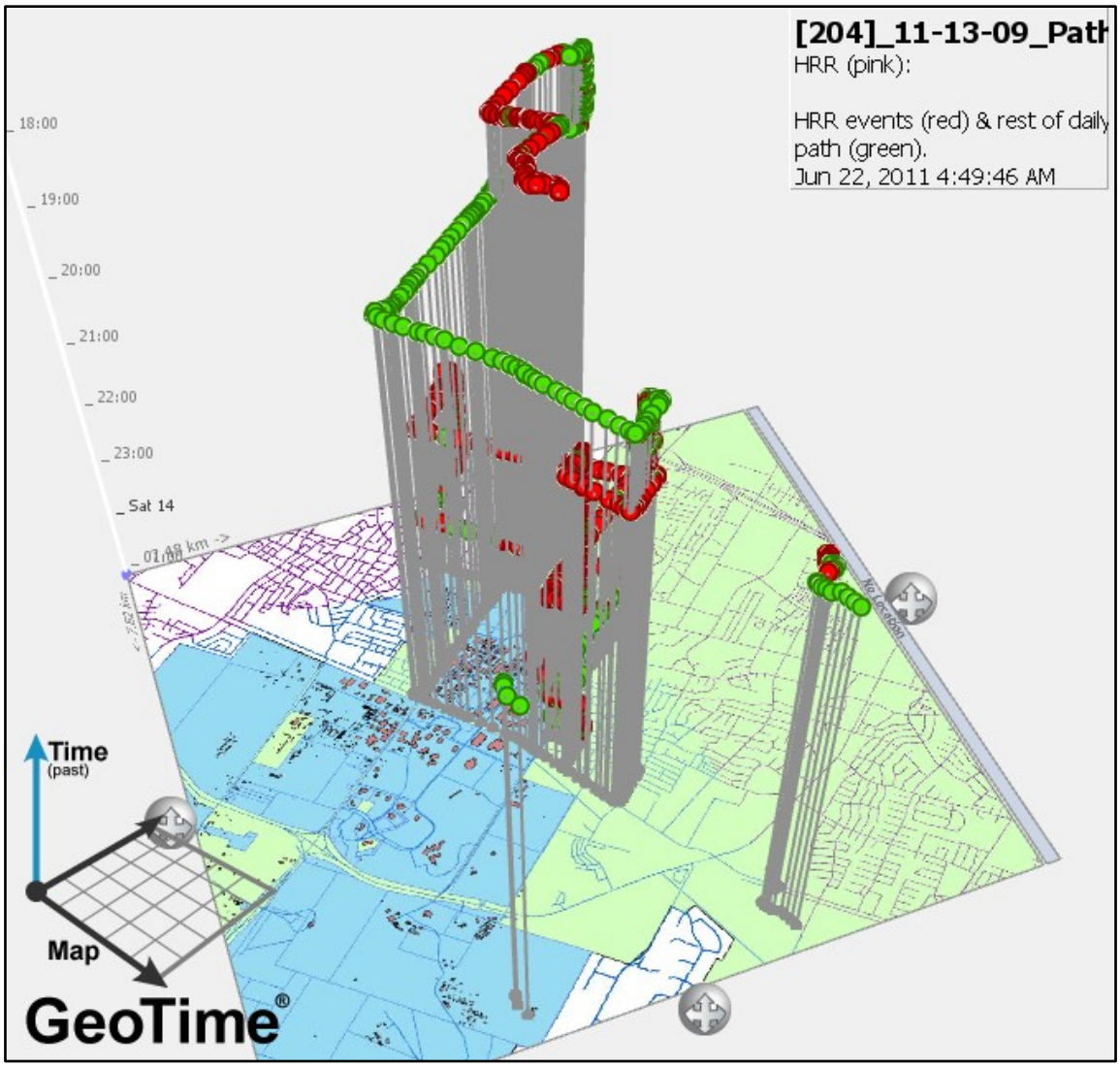



**Figure 38.** Participant 204: map of 11/13/09 daily path
Note: HRR events are marked in red.

The third monitoring session starts off showing the participant walking to campus (Figure 38). An HRR event lasting from 11:04–11:45 (41 minutes) and 11:46–11:56 (10 minutes) illustrate physical activity and the fact that he feels the pressure of having a lot to accomplish today. *"…this is my first log of Friday the time is about 11 o'clock. Um*

*currently I am walking toward the O&M building because I need to print off my essay because I didn't know how to print it in the SCC in color. So that's what I'm doing now. My pulse is, wow, a hundred cause I'm I guess I'm walking. Today I'll probably feel stressed more stressed today out of all of the two other days because I have a lot going on a lot going on, as in ring dunks and parties to go to tonight. So I'm kind of I guess I could say stressing out because I have to get my school work done so that I can go out tonight. That's probably the reason behind my whole stress I guess"* (Entry 12: 11/13/09 @ 12:03). The participant was accurate in his prediction that he would experience more HRR episodes today. Between 11:04 and 16:30 there were ninety-one HRR events, a mixture of a short and longer than a minute events, and three episodes ranged 10 minutes or more. At 16:30 he takes the time to give a recap of his busy day but does not relate time to place except for describing the day's progression chronologically. His day was spent accomplishing academic tasks and attending classes earlier in the day, and later (around 18:30) getting ready for and attending "Ring Dunk" night celebrations (Figure 39).

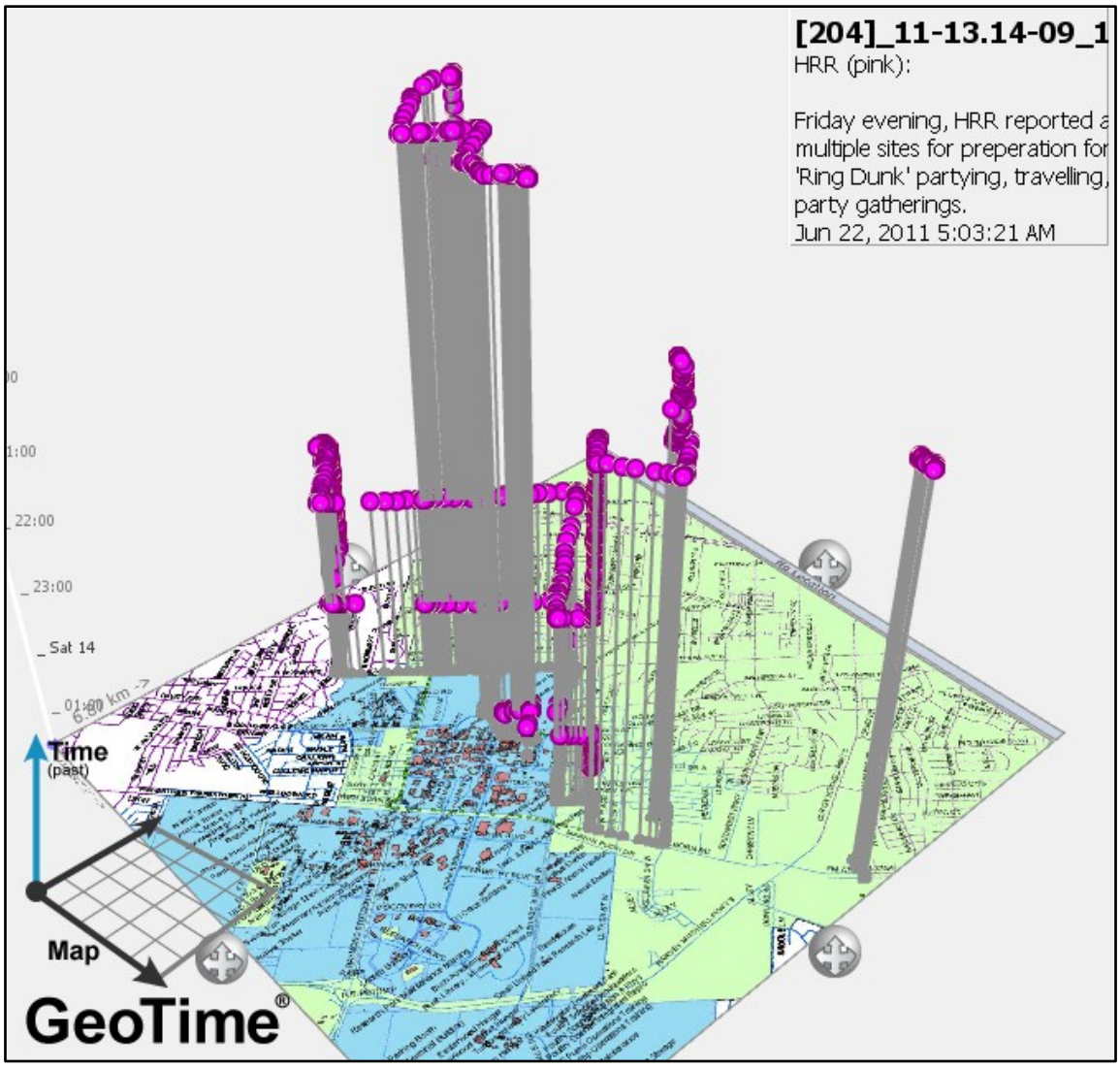



**Figure 39.** Participant 204: map of HRR events during a busy day, 11/13/09 and leading into the next day, 11/14/09.

***Participant 205***

GPS/HR data were not recorded for this participant. The only data collected are audio diary entries (Appendix H).

***Participant 206***

Because of equipment difficulties there are no maps (geographic location data) to accompany the audio diary accounts of this participant, but there is HR monitor data. During the first monitoring session she reports being in her dorm. "*...yeah I'm just watching a movie for couple of hours and chilling"* (Entry 1: 11/15/09, @ 16:19). Between 16:20 and 19:20, which accounts for the time spent watching movies/chilling, she experienced twenty HRR episodes, the majority of them only lasting a few seconds. In this time range the participant did experience six HRR events that lasted a minute or more, with the longest starting at 17:38 and ending at 17:49 (11 minutes). *"Okay, it's 7:40 and (pause) I just took a nap and my heart rate went up. So I was just letting y'all know that, that's why my heart rate went up (little nervous laugh, pause). Okay (sigh)"* (Entry 2: 11/15/09 @ 19:38). Part of the aforementioned 11-minute HRR episode took place during this audio entry. From 19:20 until 21:22 she experienced thirty-two HRR events, most lasting a few seconds but six episodes continued for approximately 1 minute. Only one of the stressors for 1/15/09 was reported by the participant.

The second monitoring session begins a few minutes prior to 7:30 and there the participant experiences forty-three HRR events leading up to her 9:00 class. Most of the events are brief (less than a minute) but there are seven that last a minute or more. For example, she experiences an HRR event from 7:30–7:53 and another from 8:24–8:31, both unreported and lasting longer than 5 minutes. The episodes between 7:30 and 9:00 are primarily related to preparing for and travelling to class. *Okay, so I just walked to class and (pause) I walked up 2 flights of stairs. So (pause) I'm a little (breathing heavy,*

*pause) breathing heavily right now, (pause) I'm a little stressed"* (Entry 3: 11/17/09 @ 8:46). The HRR episode from 8:43–8:50 corresponds to the participant walking up stairs to reach class and, given the timing of the reported stress, it seems to be associated with class (authoritative constraint). Additionally, between 9:00–11:00 the participant experienced thirty-four HRR events, and twelve out of thirty-four were longer than 1 minute.

*"Well, it's 2:09 and I am about to take a nap. So my heart rate may or may not (ah) increase. Just letting you know if you get a sudden shock or something I might be having a nightmare because I had one last night; (little laugh) alright. Bye"* (Entry 4: 11/17/09 @ 14:08). The participant experiences fifteen HRR events between 13:30–14:08 leading up to this audio entry. Seven of the episodes are a minute or longer and two of the episodes from 13:47-13:53 (6 minutes) and from 13:55-13:59 (4 minutes) happen just before she takes a nap, which makes sense in light of later audio entries that mention sleep as her primary stress-coping strategy. During sleep the participant experiences three HRR events, all a minute or less. Over the remainder of the monitoring session she encounters periodic stress exposures with the longest lasting 23 minutes, from 16:37-17:00, and in the participant's audio diary the only explanation is studying. *"You know I accidentally wore my (ah, little giggle) heart rate monitor and my GPS too long, so (nervous laughing) that's why I had it on for so long today. Alright, Sorry (apologetically), got caught up studying"* (Entry 6: 11/17/09, 18:14).

The third monitoring session begins a few minutes before 8:00 but the participant does not make any diary entries until shortly before taking a History exam, which she is

experiencing as a stressor. *"Well I'm about to take a test in history and I can see that my heart rate is going up. So (pause) just letting you know. Alright, (sigh) Bye* (in background hear her saying, *"it kind of stresses ...")"* (Entry 7: 11/18/09, @ 12:26). In the hour prior to the exam she had twenty-one HRR events; most were brief but there were seven episodes lasting a minute or longer. The longest HRR event was 14 minutes in duration. For the next hour after arriving for the exam the participant experienced thirty-one HRR events, with the longest event lasting 6 minutes.

The participant, in this entry, explains some situations in her life that cause stress and gives insight into her primary coping strategy. She interprets stress associated with studying as a biological constraint. *"So, it's usually (sigh) when I talk to someone else and they make me angry or just I guess just like I am annoyed at them. So I come in and I take a nap because it helps me calm down. And (ah) as far as studying I tend to get stressed in study environments. (Ah) so that would be B, so like last night when I was studying and this morning, when I walk into a place to study I immediately start getting stressed out because of all the materials that I have to study. So that's usually why. And then (pause) I'm about to take a nap again. I did not feel like going to class today because I took a test and (pause) that was really; I mean it wasn't that stressful but I got a little stressed. And that was around 12 o'clock was when I took my test. So (sigh) I took that test today and I didn't get a lot of sleep last night. So I am going to take a nap now, so I guess just because of B because I am in my room and it is causing me to think about homework and stuff. So I always just take naps whenever I start thinking about too much stuff"* (Entry 9: 11/18/09 @ 15:49). No GPS/HR monitoring data was recorded

immediately before or after this entry but in the hour preceding the entry (14:49–15:49) twenty-one HRR events were recorded, with four lasting a minute or more. The last data record was logged at 15:29.

***Participant 207***

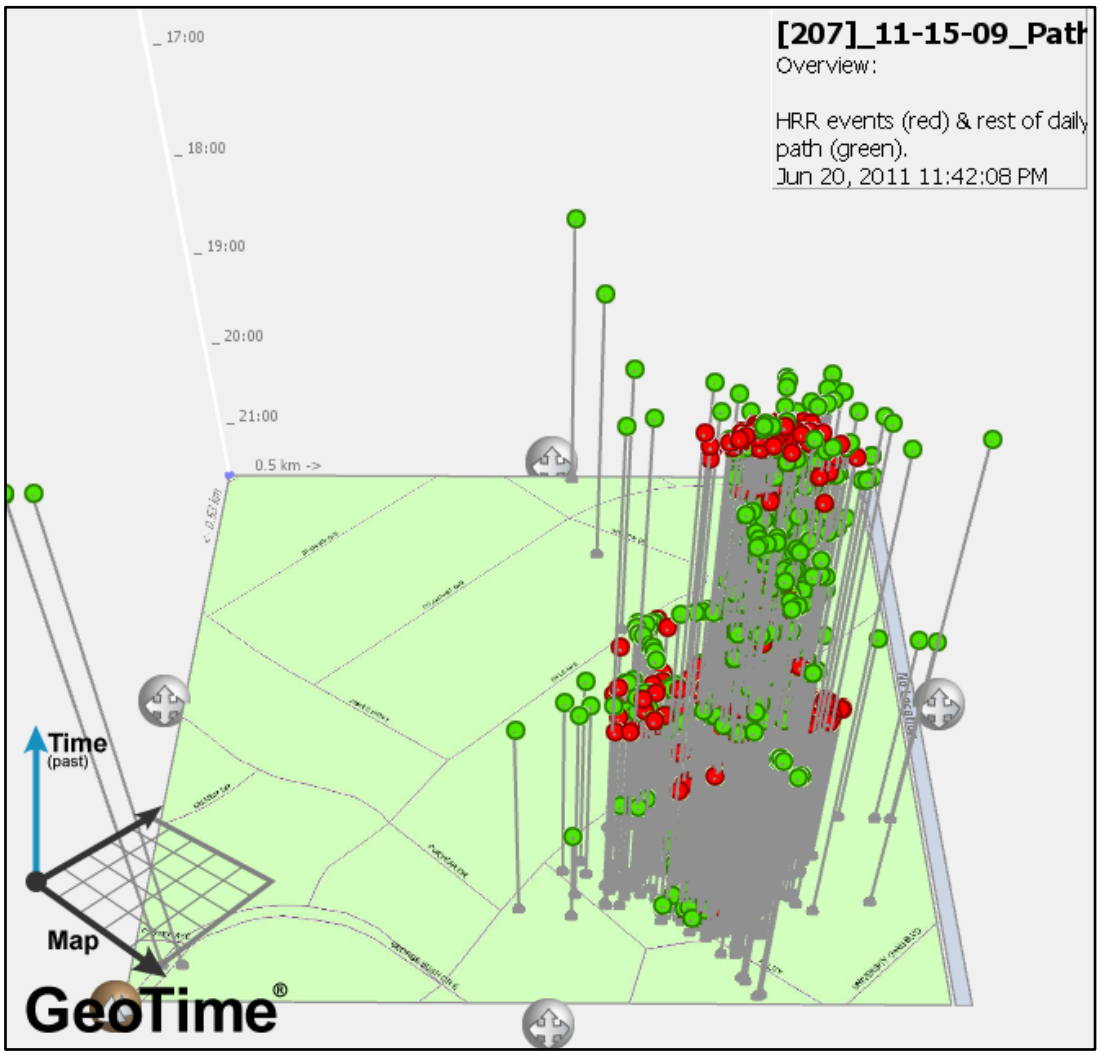



**Figure 40.** Participant 207: map of 11/15/09 logged daily path.
Note: HRR events are marked in red.

The participant's first monitoring session on 11/15/09 was the only period where both geographic and HR data were recorded (Figure 40). Spatial data were not recorded for the two following sessions. During this first session the majority of the participant's time was spent in one location that is assumed to be his base or a place where he spends time (Figure 41). Seventy-three brief HRR events occurred in the 5 hours, with seven lasting a minute or more. Without significant change in location or an account to accompany the spatial data the source of the stressors is unknown.

The majority of audio diary entries were recorded by this participant on 11/17/09. Starting at 15:28 he experienced three HRR events, two of them lasting longer than 1 minute, with the most sustained episode ranging from 15:32–16:20 (48 minutes). The audio diary account attributes the HRR to physical activity. *"I am about to go work out so my heart um might go up a little bit alright"* (Entry 3: 11/17/09 @ 15:27). The length of the work-out is designated by an entry afterwards reporting that he will be removing the monitoring equipment to shower.

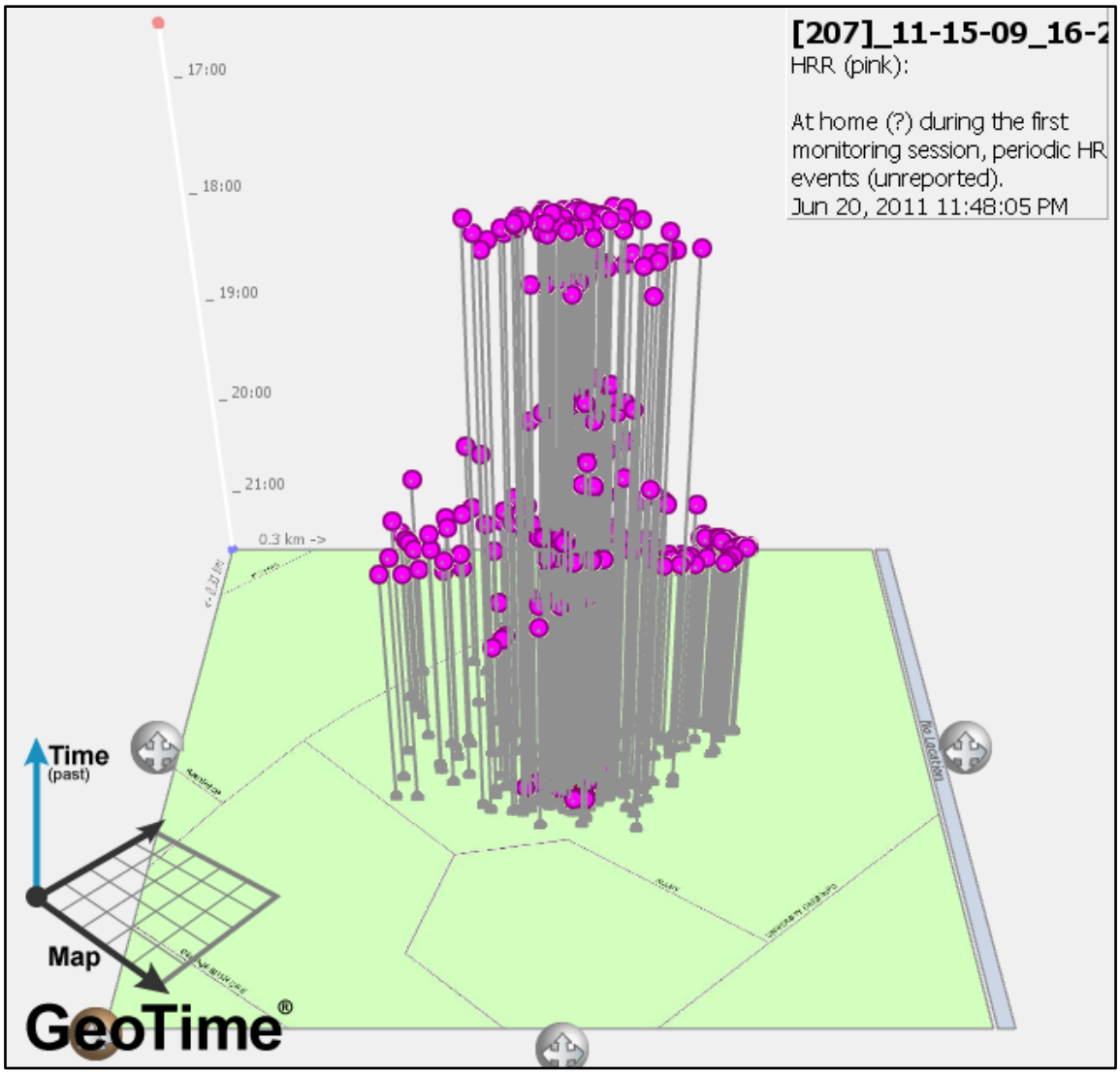



**Figure 41.** Participant 207: map of HRR events during the first monitoring period (16:00-22:00).

*"Alright, I just jumped out of the shower and I put my heart thing back on and I'm feeling a little stressed out because I have a study group in 30 minutes. And I have to be there really soon, so that means I have to get ready and do my hair. Um… I think that would probably be um… B type stress; a limitation of my own biological ability because I don't have the ability to get be fast enough to get ready fast enough. Um… and I'm little stressed out about um… my study group because I'm not very familiar with all the people that are in it so that will be C type stress"* (Entry 5: 11/17/09 @ 16:39). Starting at 16:37 the participant experienced a sustained HRR episode that lasted until 17:23 (46 minutes) and this was followed by forty brief HRR events up until 18:09, which is an hour after arriving at the study group. *"Alright I'm about to go to my study group. Um it will be inside of my dorms at Cambridge... But um I have a little bit of C type stress. I'm a little anxious because I don't know very many people in my study group and um I have a big test coming up tomorrow so I hope it's valuable"* (Entry 6: 11/17/09 @ 17:08). Pronounced HRR activity occurred as a precursor, in anticipation of an uncomfortable situation with possible academic ramifications.

***Participant 208***

This participant reported having an exam tomorrow, needing to spend the day studying, and anticipating experiencing stress. *"It is 2:26 on Tuesday, November 17th. I have a test tomorrow that I'll be studying for today. So that might get me a little anxious…nervous and stressed. I have a lot of things on my plate today"* (Entry 3: 11/17/09 @ 14:28). *"I just called a lady concerning an interview for my hiring [unclear words] that makes me nervous"* (Entry 4: 11/17/09 @ 14:42). The monitoring session started at 14:25, from 14:34–15:14 (40 minutes). She had a significant HRR episode, which overlapped in time with a conversation regarding a job that caused anxiety. Over the 11-hour monitoring session from 14:25–1:53 (11/18/09), the participant experienced just over 100 HRR episodes (Figures 42 and 43). A quarter of these events were a minute or more and seven of them lasted 10 minutes or more.

The third monitoring session started with an authoritative constraint stressor relating to the exam that she doesn't feel well prepared for. *"This morning at nine o'clock I had a test. I really didn't study that well for it so it's kind of stressful"* (Entry 6: 11/18/09 @ 11:13). From immediately before the exam (Figure 44) until approximately 10 minutes after the exam began, the participant had three HRR events, the longest one lasting from 8:56–9:01 (5 minutes). After that the GPS unit recorded location but the HR monitor was intermittent.

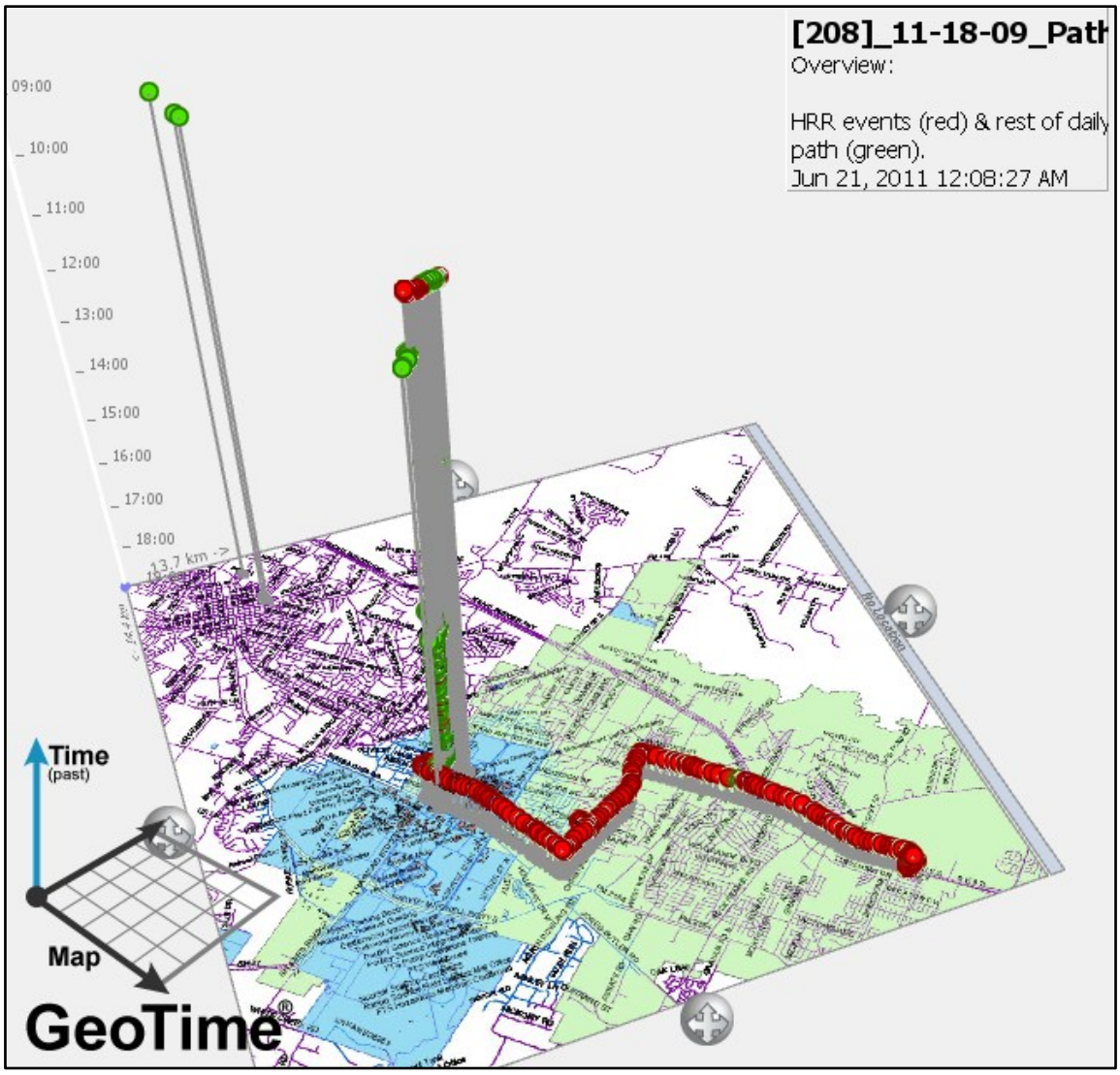



**Figure 42.** Participant 208: map of 11/18/09 daily path.
Note: HRR events are marked in red.

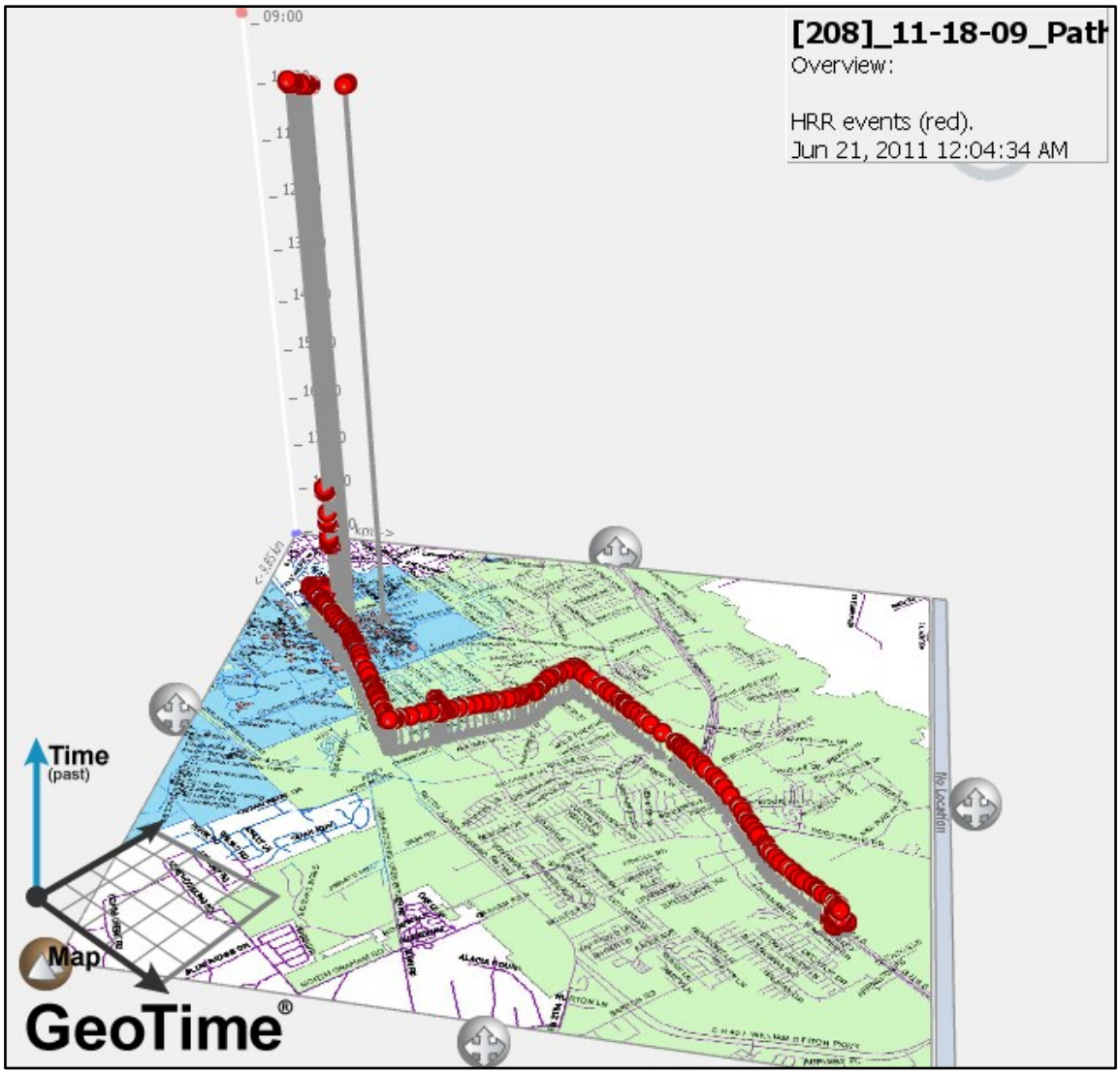



**Figure 43.** Participant 208: map of 11/18/09 logged HRR events.

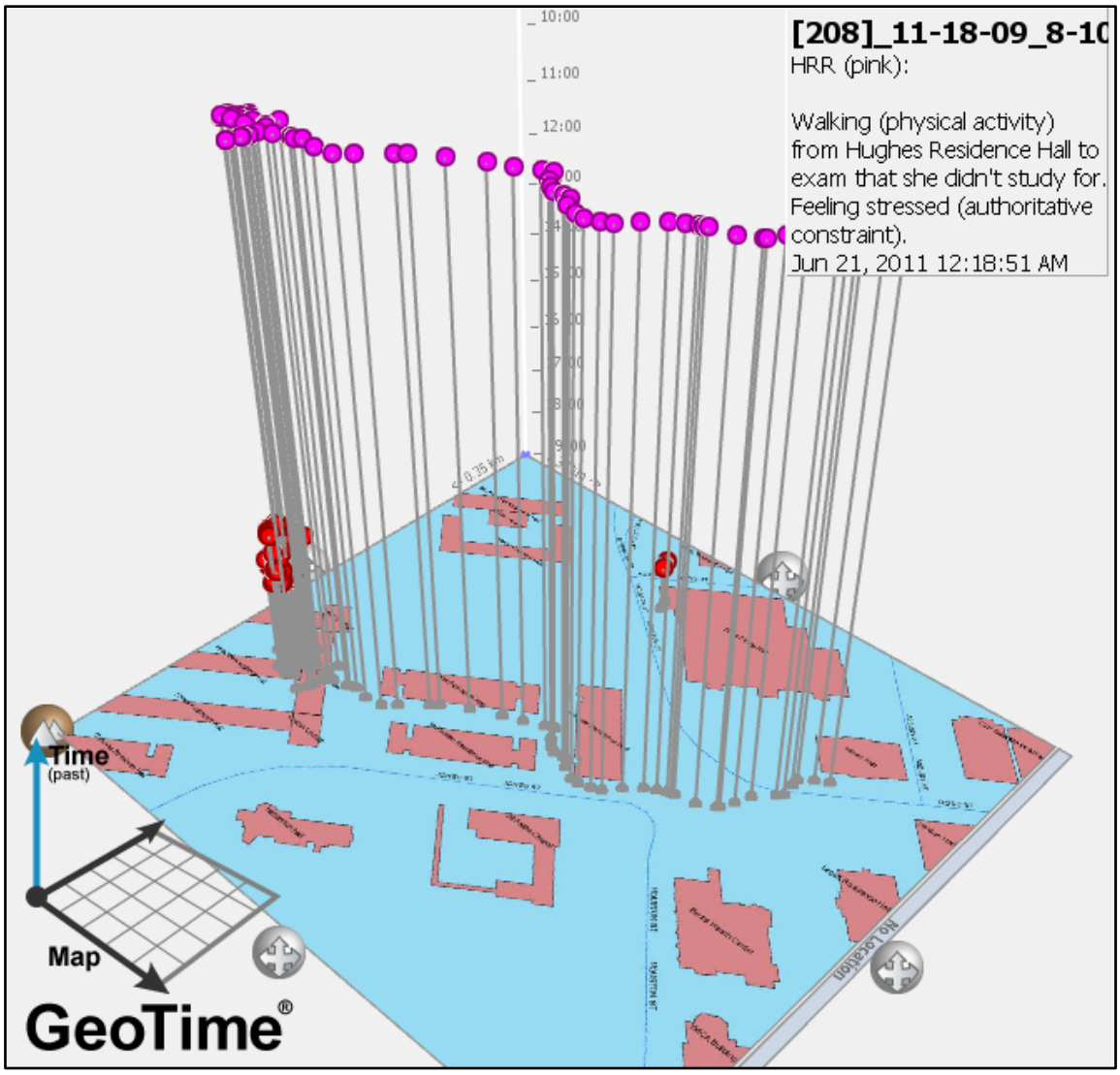



**Figure 44.** Participant 208: map of HRR events (8:00-10:00).
Note: HRR events are in pink and show the participant walking from her residence hall to the exam.

***Participant 209***

This participant's monitoring sessions were lacking complete data records. On 11/22/09 spatial and audio data were not recorded but there is HR data. From 19:50–01:29 (11/23/09) she experienced sixty-five short HRR episodes, with nineteen lasting a minute or longer (Figures 45and 46). With explanatory data missing there is no way to piece together the participant's possible stressors.

The GPS/HR monitor recorded brief HRR events at 12:05 and at 12:11, but they fall short of the reported stressor (physical activity) by about 25 minutes. *"I'm running with my puppies and wrestling with them and running around the house otherwise before this I've been resting and watching TV [sounds a bit out of breath]"* (Entry 1: 11/23/09 @ 12:30). The spatial data do correspond to her reported location. *"Trying to start my homework but procrastinating [could hear male voice on TV in the background]"* (Entry 2: 11/23/09 @ 12:50). Neither the participant's audio entries nor her HR fluctuations reflected any stressful events during this monitoring session.

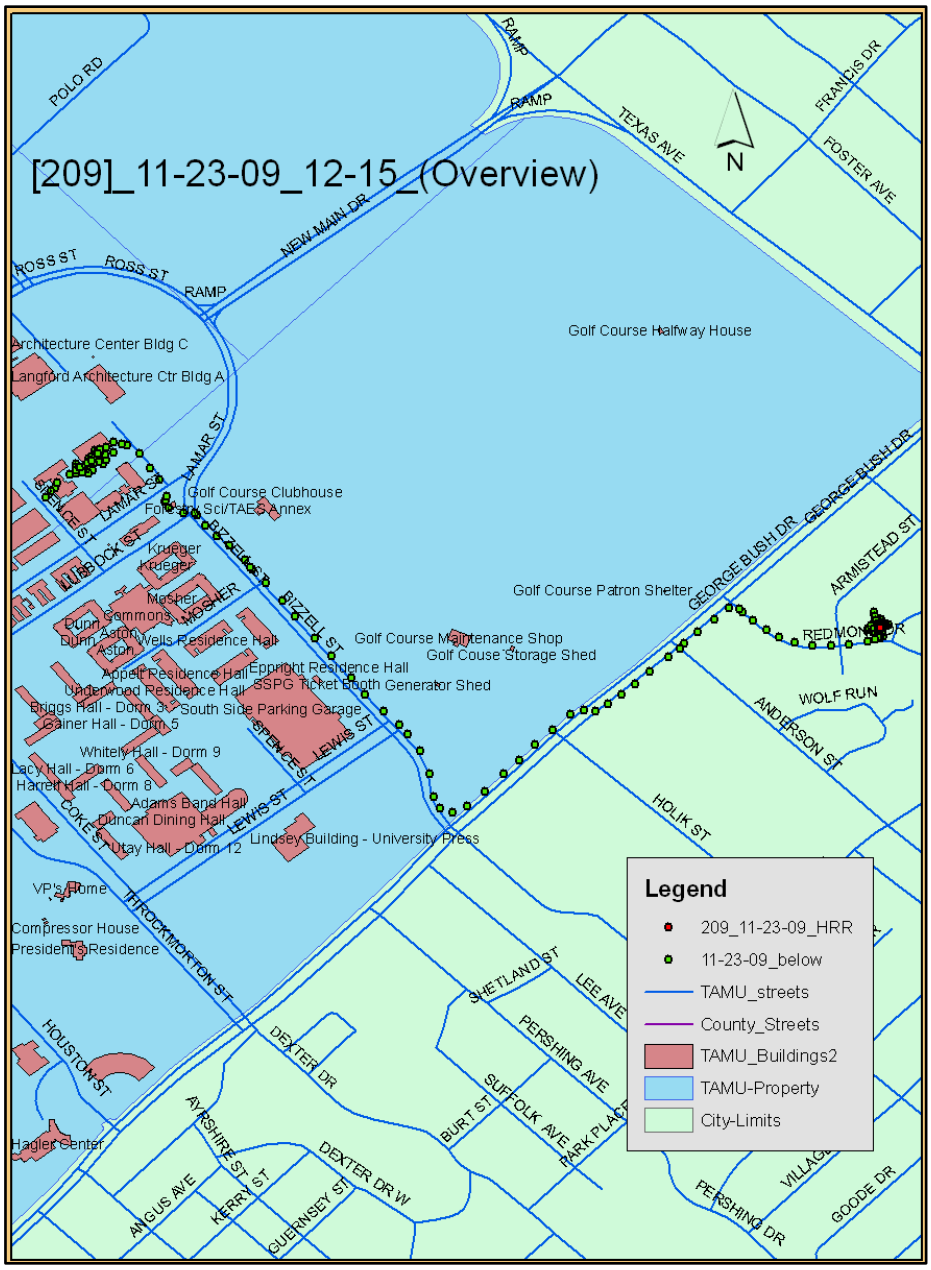



**Figure 45.** Participant 209: map of 11/23/09 daily path.
Note: HRR events are marked in red.

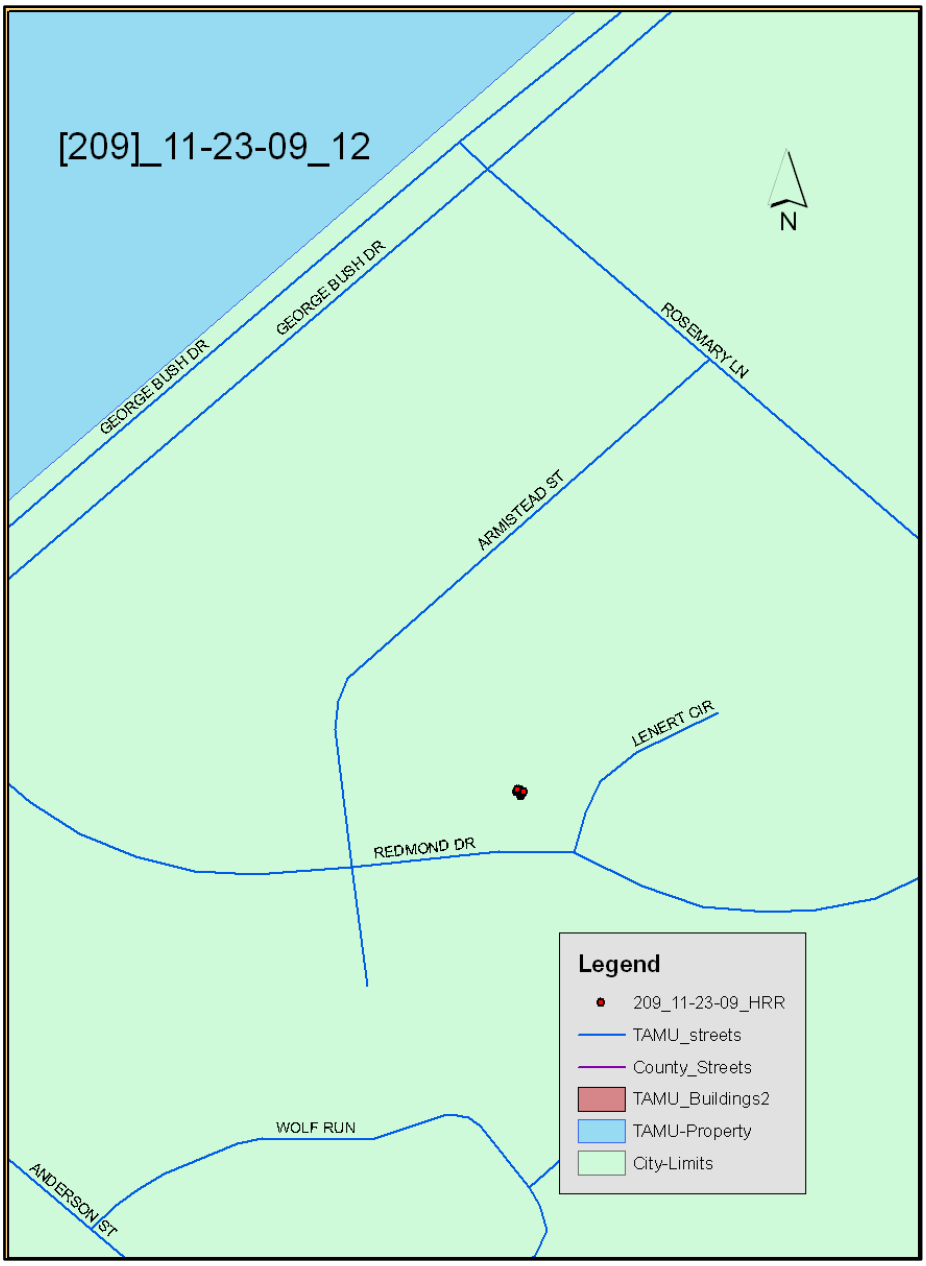



**Figure 46.** Participant 209: map of 11/23/09 logged HRR events.

***Participant 210***

During this participant's first and second monitor sessions she provided two retrospective audio entries but due to missing GPS and time data the locations mentioned cannot be linked to the recorded HR data. *"When we arrived back I got a sick feeling in my stomach about a week to come and that would be a stress 'A' factor. After cleaning the bus and running upstairs with my buddies and I left the dorms to decide about dinner, which turned into an argument as always 'C' stress factor. As we walked to Northgate some of my buddies started to smoke and we started fighting about that because my father is suffering from some smoke related health issues. Dinner went somewhat smoothly and I got my mom I called my mom on the way back. She told me how my dad's surgery went and how everyone at home is doing. After we got back to the dorm and I finished talking to my mom my roommate and I got ready for our outfit meeting a stress 'A' factor and we complained about the lack of effort from my buddies"* (Entry 1: 11/16/09 @ 8:18). On 11/15/09 she experienced a total of thirty-six HRR events between 15:00-20:07. Out of the thirty-six episodes nine are a minute or more in duration and four of those are 10 minutes or more in duration. Four events experienced from 17:55–18:05 (10 minutes), 18:16–18:39 (23 minutes), 18:40–18:50 (10 minutes), and 19:20–19:46 (26 minutes) correspond to her possible dinner time and the reported stressors that occurred. The events that transpired on the evening of 11/15/09 clearly illustrate some of the stressful factors in this participant's life, such as perceived future challenges, disagreements with friends, family health issues, and Corps obligations. The

audio entry, though it alluded to dinner time being related to some of the day's stressors, did not give specific time information to connect with GPS/HR monitor data.

For the second monitoring session, on 11/16/09, HR data and a retrospective audio entry were recorded seven days later. Between 8:08–18:03 she experiences seventy-five HRR events, thirteen occurrences lasting 1 minute or more, and eight of those ranging 10 minutes or longer. *"On Monday our senior hell week began. So when we woke up our seniors had yelled at us but I didn't start my heart rate monitor until a couple hours afterwards after drill and everything. And I was worried to go out in the hallway because I had not met everyone. We needed to speak 3-deep, which included their name, major, and hometown and I didn't know very many of them. I got out of the dorms pretty fine but I had to wait an hour for my buddies who were supposed to come get me since we needed the buddy system for the week. They took an hour because they had slept through their BQH, the study hour that is mandatory for the band and I was pretty upset about that and then they took forever to get dressed. We then had to do push-ups to get onto the drill field to do an etching, which was an assignment we were given by our seniors. But that didn't cause too much problem so I got that done pretty easily… For class I was kind of worried about the upcoming test but it didn't faze me too much. I then had a drilling ceremony for military science lab and we walked around marched around for about an hour and a half, which got tiring and then I ran upstairs and we got smoked by our seniors for not doing the etchings properly. And we all went out to the drill field together. We had to do push-ups to get on and off and got smoked on the drill field while each person individually did their etching"* (Entry 3: 11/23/09 @ 11:47). The eight

lengthier HRR episodes ranged from 10:03–10:13 (10 minutes), 10:16–10:30 (14 minutes), 11:02–11:12 (10 minutes), 12:07–12:23 (16 minutes), 13:30–13:44 (14 minutes), 14:40–14:50 (10 minutes), 16:15–16:30 (15 minutes), and 17:21–17:55 (34 minutes), but without the explanatory power of spatial and specific time data connect with her audio entries they cannot be accurately linked to reported stressors.

Her third monitoring session included all of the data components, spatial, HR, and audio entries (Figures 47 and 48). The audio entries give situational and some spatial information but they do not provide specific times to accompany the details. *"On Tuesday I started my second ten hour thing... And then I decided to take a nap because I hadn't been getting much sleep. Uh and I went to lunch and hung out with a lot of the band Corps members it was a lot of fun and it help me relieve my stress"* (Entry 4: 11/23/09 @ 11:49). The participant spent time with friends for several hours after having lunch at Sbisa (Figure 49). Between 12:00–15:00 she experienced twenty-six HRR events, some of which are attributable to having fun with friends. Seven of the HRR episodes were over 1 minute and two of those, from 14:07–14:21 (14 minutes) and 14:58–15:07 (9 minutes), last longer than 5 minutes.

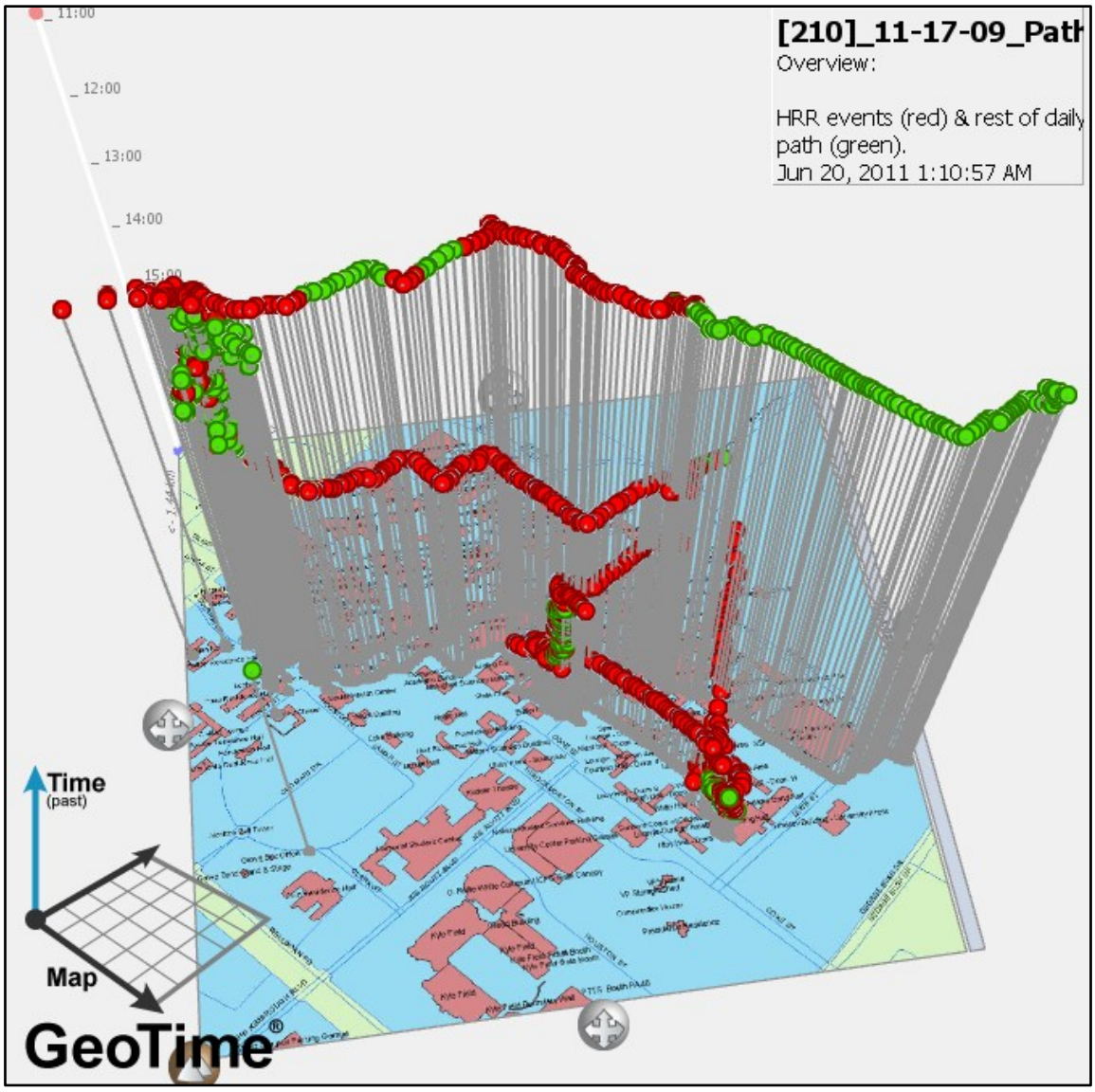



**Figure 47.** Participant 210: map of 11/17/09 daily path.
Note: HRR events are marked in red.

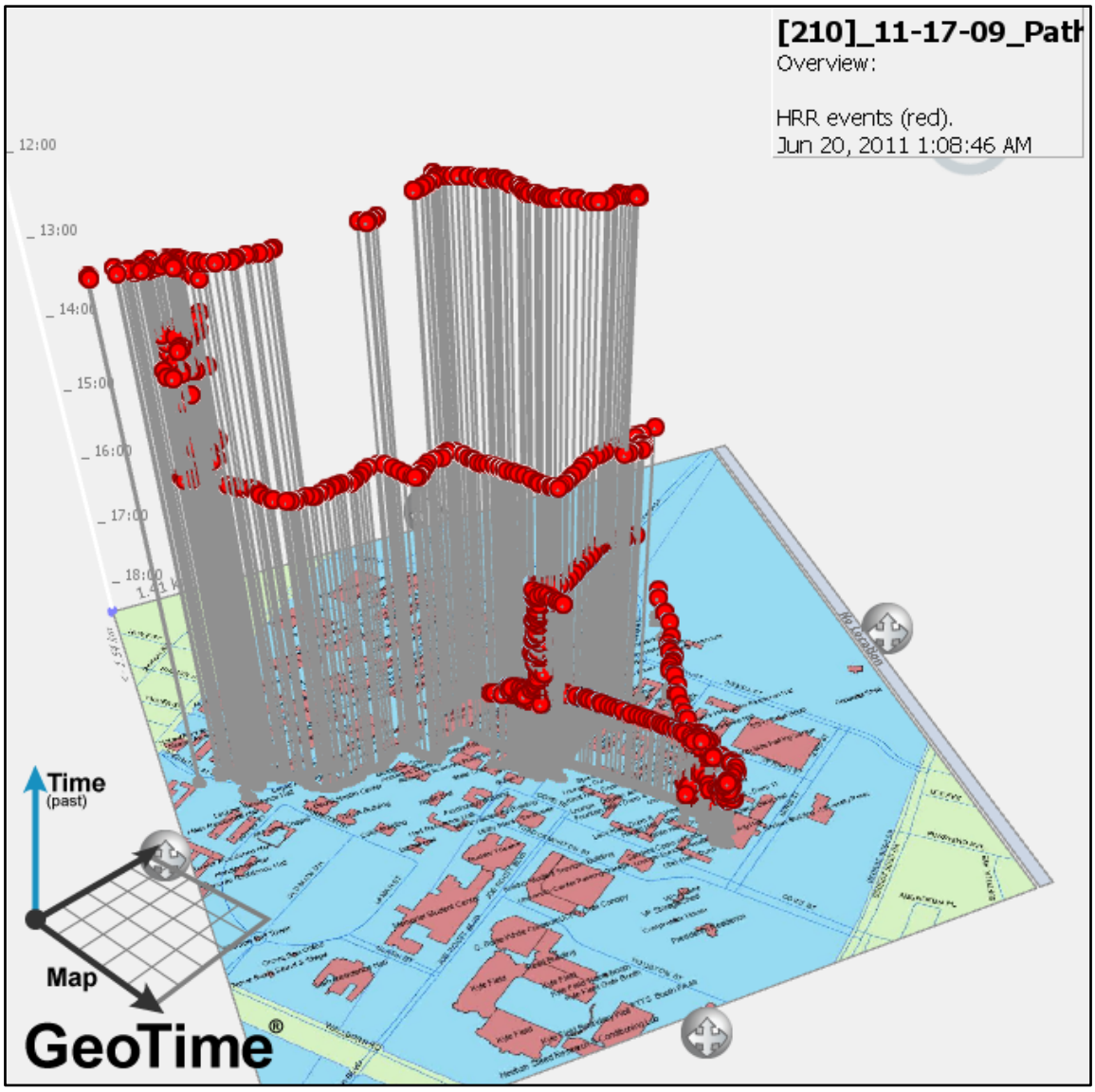



**Figure 48.** Participant 210: map of 11/17/09 logged HRR events.

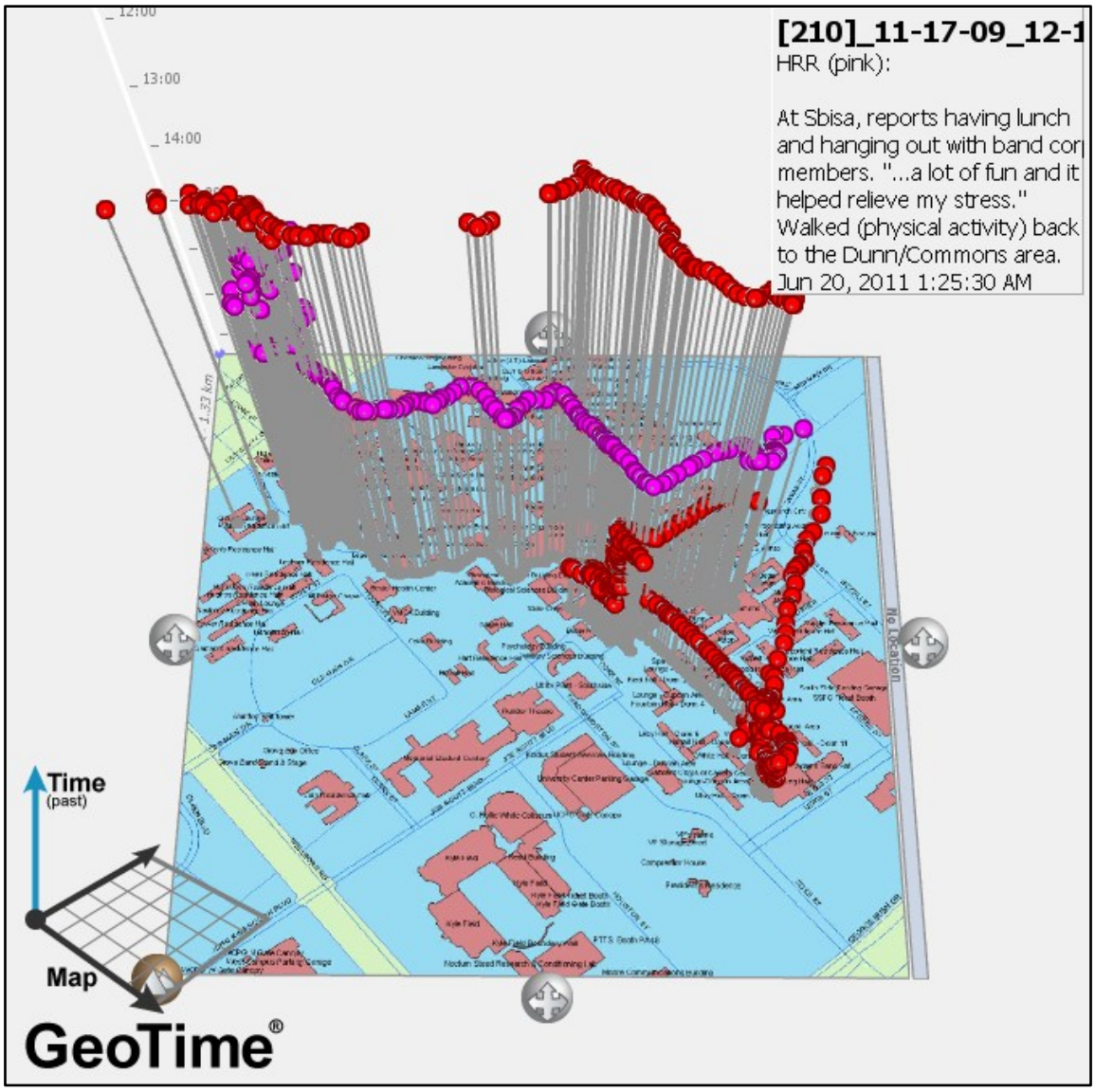



**Figure 49.** Participant 210: map of HRR events (12:00-15:00).
Note: HRR events are in pink and show participant spending time in Sbisa Dining Hall with friends and walking back to dorm area.

Between 15:09 and 17:00, which entailed the participant walking to and sitting in Chemistry class, she had thirty-five HRR events, five lasting a minute or longer (Figure 50). Although the focus of Chemistry class was on exam preparation, she expressed apprehension about issues related to the Corps' "senior hell week," not academics. *"Then I went to a chemistry class and we prepared for the next test. On the way back to class my heart rate went up because I was nervous about whether or not we'd be getting smoked again and if I would remember everyone's names. Also I had to head back alone because no one none of my buddies were out of the dorms in order to take me back and I was worried that the buddy system would apply during that time. Luckily no one saw me and I was able to get to my dorm…"* (Entry 4: 11/23/09 @ 11:49). The participant's longest HRR episode lasts from 17:09–17:45 (36 minutes) and corresponds to her reported nervousness when heading back to the dorms after class (Figure 51). Overall, in the period from 11:00–18:28 she experienced seventy-nine brief HRR events and twenty-four of them lasted for a minute or more.

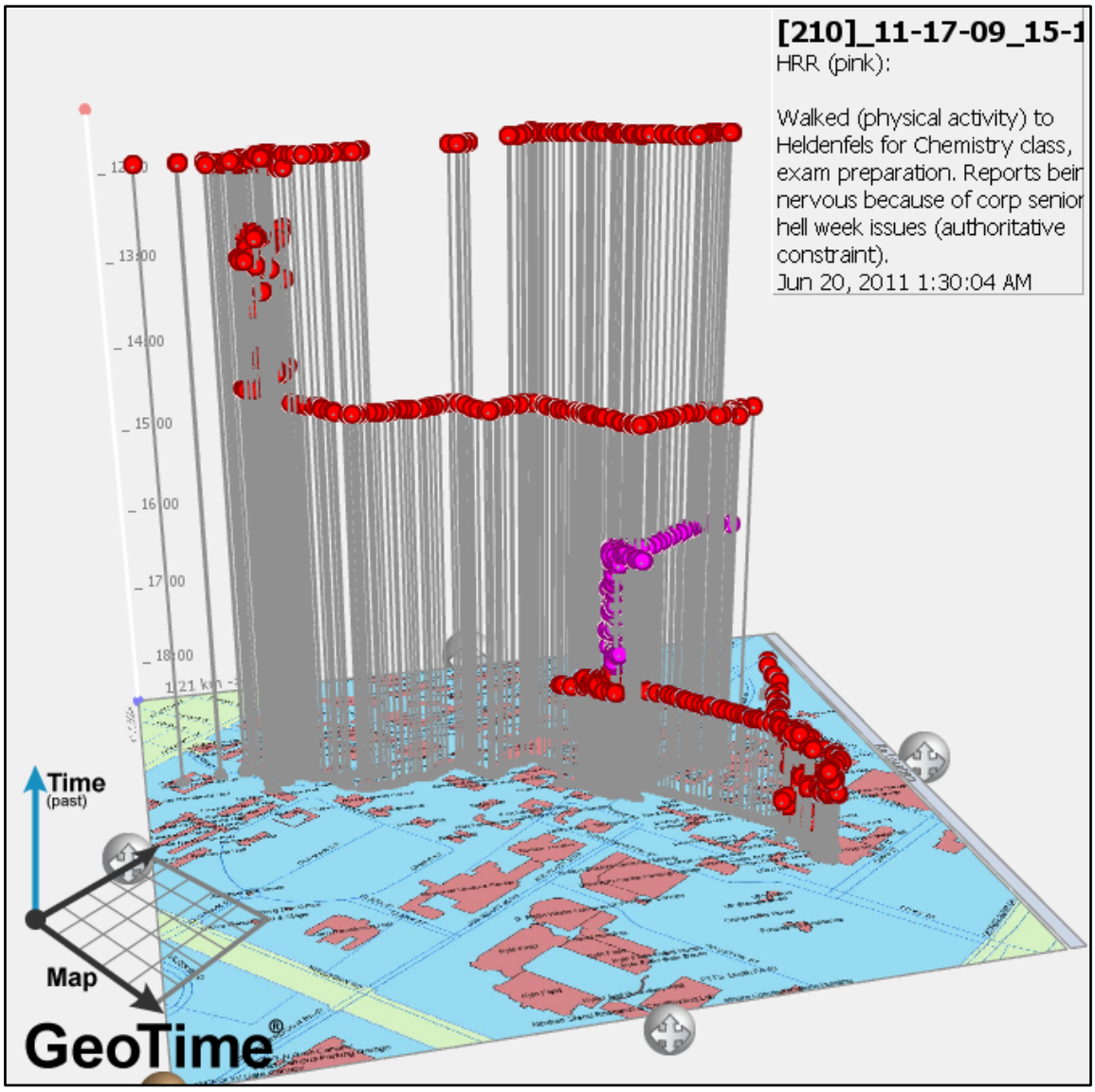



**Figure 50.** Participant 210: map of HRR events (15:00-17:00).
Note: HRR events are in pink and show the participant walking to Heldenfels for Chemistry class.

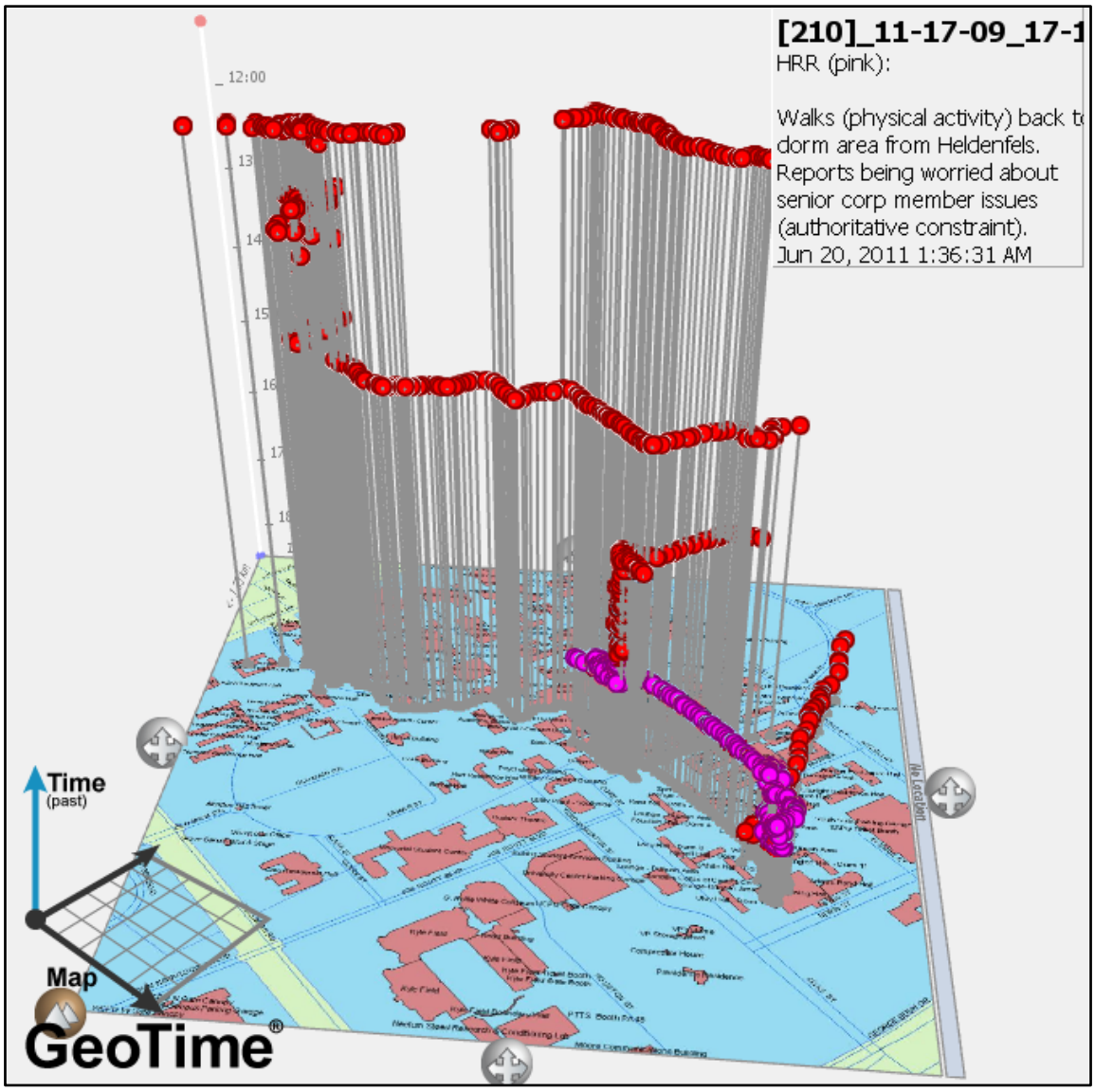



**Figure 51.** Participant 210: map of HRR events (17:00-18:00).
Note: HRR events are in pink and show participant walking to dorms, with worry attributed to "senior hell week" rules.

***Participant 211***

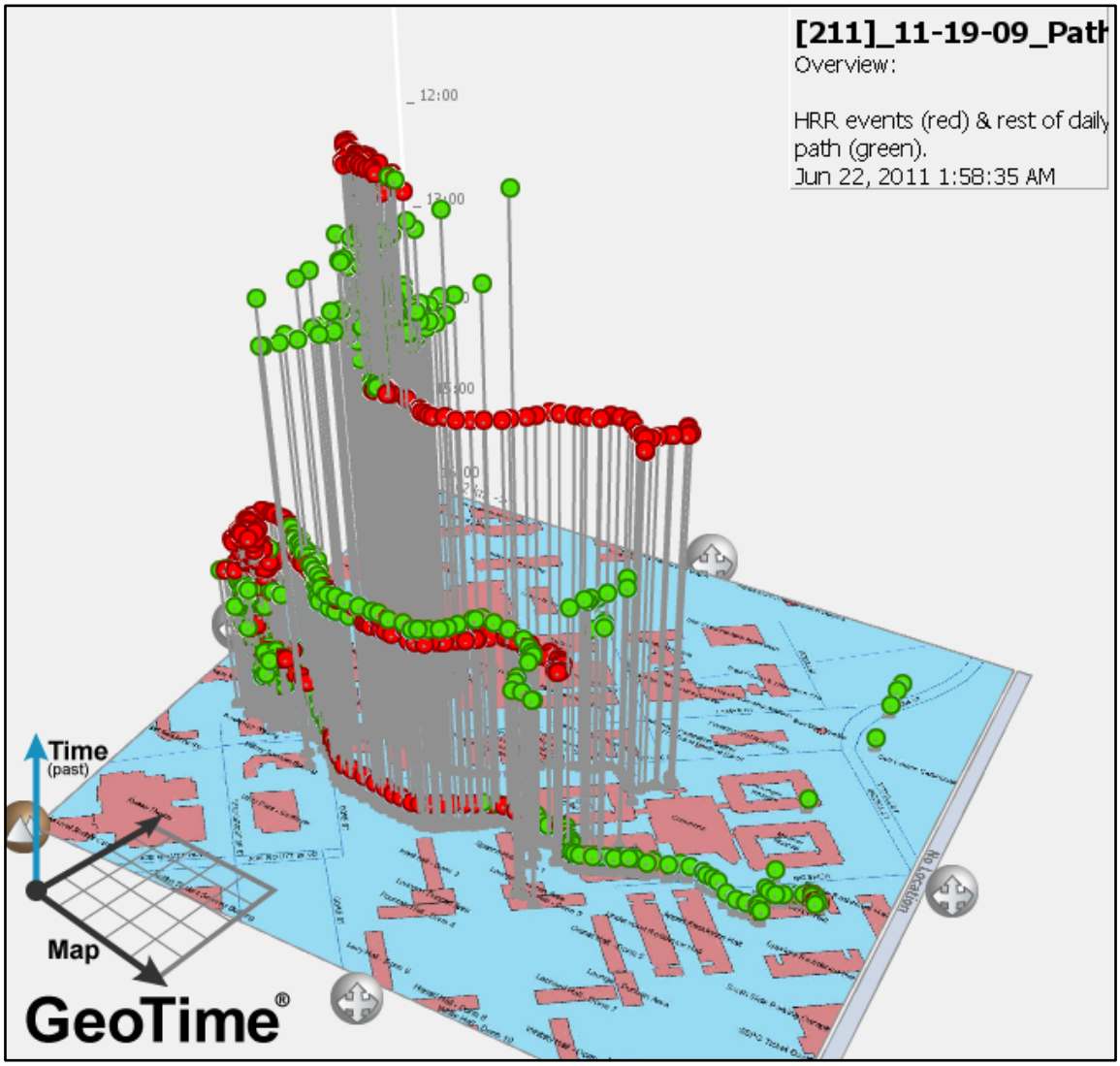



**Figure 52.** Participant 211: map of 11/19/09 daily path.
Note: HRR events are marked in red.

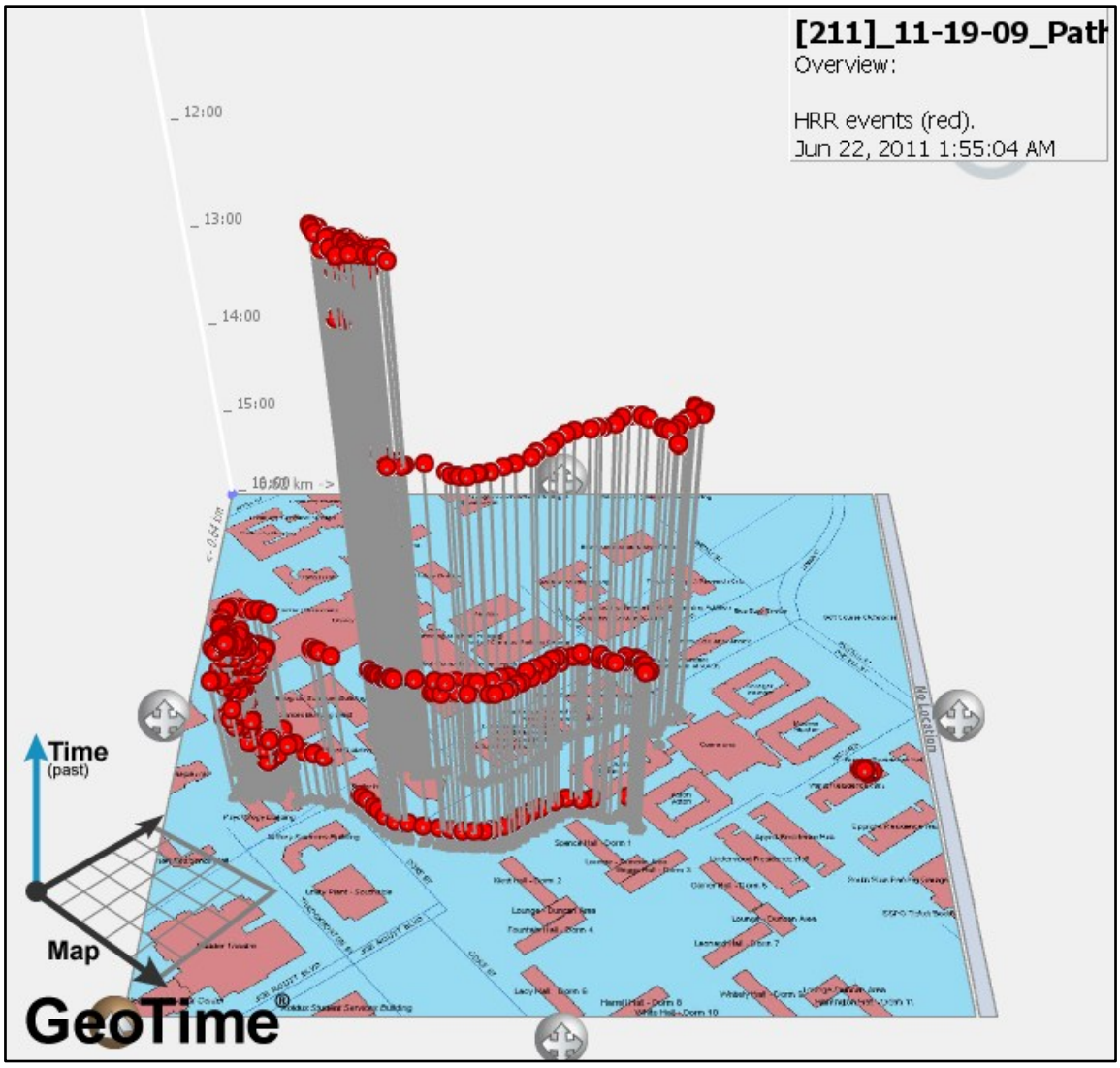



**Figure 53.** Participant 211: map of 11/19/09 logged HRR events.

All of the audio diary entries reported by this participant were retrospect by at least a day. From beginning of this first monitoring session (11:00–16:00), the participant is experiencing HRR events (Figures 52 and 53) associated with exams (authoritative constraints). During the Chemistry lab exam (11:00–12:00) sixteen HRR events occurred (Figure 54). The first and longest episode was from 11:00–11:11 (11 minutes) and one or

two over a minute. *"It's the end of the day on Thursday and um I'm I have a I had a Chem lab final and a um Psych test. Both times I had a lot of stress so I was freaked out. I had three tests this week so I'm pretty scared"* (Entry 1: 11/23/09 @ 14:53). *"Okay so I took my Chem lab final ah it was okay. I don't know what I got on my grade yet I'm really scared"* (Entry 2: 11/23/09 @ 16:50). She expressed a lot of fear associated with the lab final even after it was completed. Between 14:00–16:00 the participant took a Psychology exam that she had also expressed experiencing a great deal of stress over (Figure 55). During that time she experienced forty-five brief HRR events, nine of them lasting a minute or more, and within the first half hour there were three of 5 minutes or more (14:08–14:13, 14:14–14:21, and 14:26–14:32). *"Ah and I took my Psych test which was really difficult. And um I'm sitting with my friend and ah talking about how I failed miserably so that was my Psych test"* (Entry 2: 11/23/09 @ 16:50).

Later in the evening after the participant had removed the monitoring equipment she reports being up late and into the next morning preparing for an exam the next day (11/20/09). *"I stayed up till three or four o'clock in the morning on both Thursday and Friday so studying for my Bio test Thursday night. And so I have my Bio test at three um I hope it goes okay it's about meiosis and mitosis and all the wonderful replication stuff"* (Entry 3: 11/23/09 @ 16:51). She expresses concern about doing well on the exam but does not explicitly say that it is a stressor.

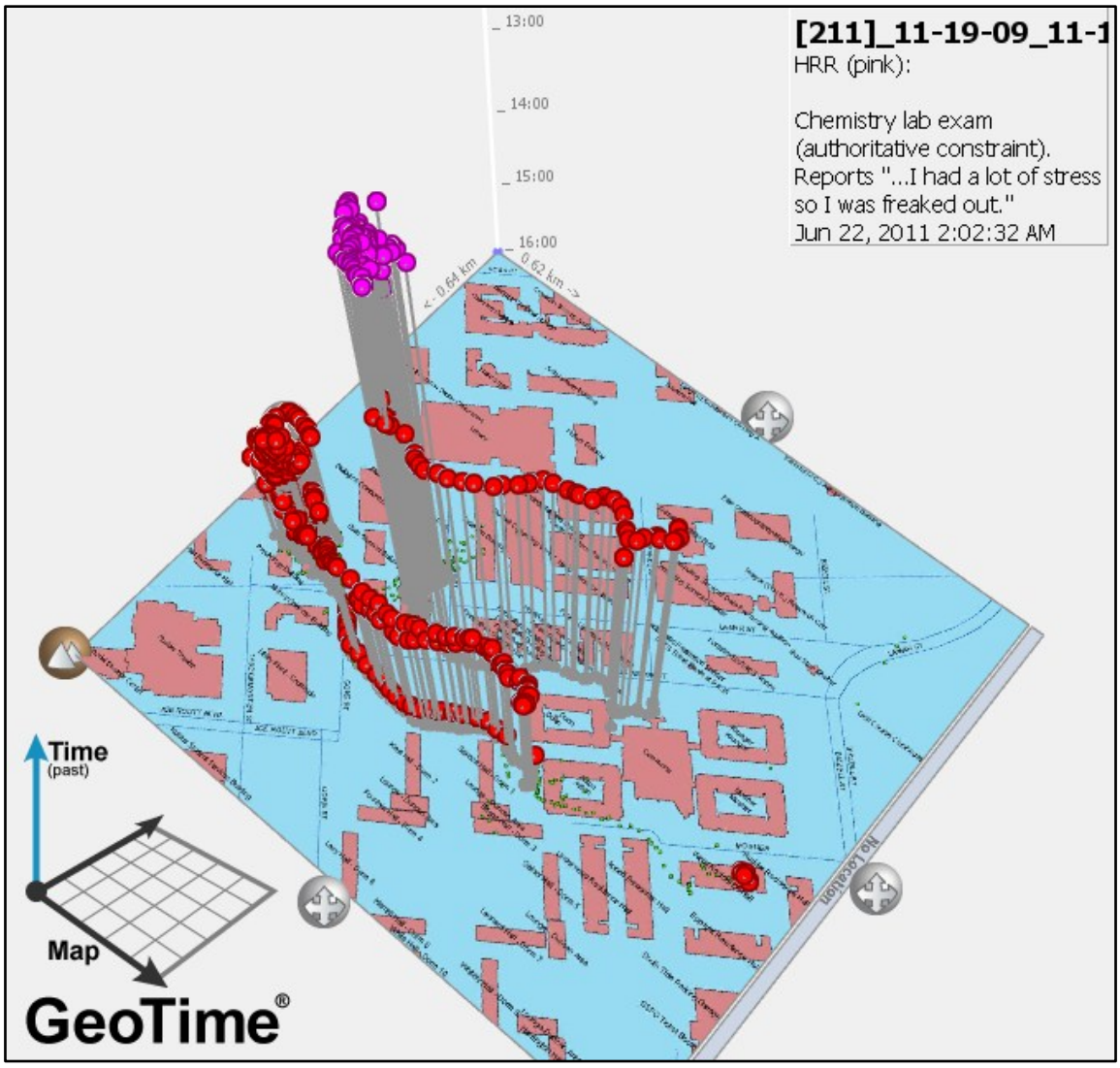



**Figure 54.** Participant 211: map of HRR events (11:00-12:00).
Note: HRR events are in pink and show elevated HR during the participant's Chemistry lab exam.

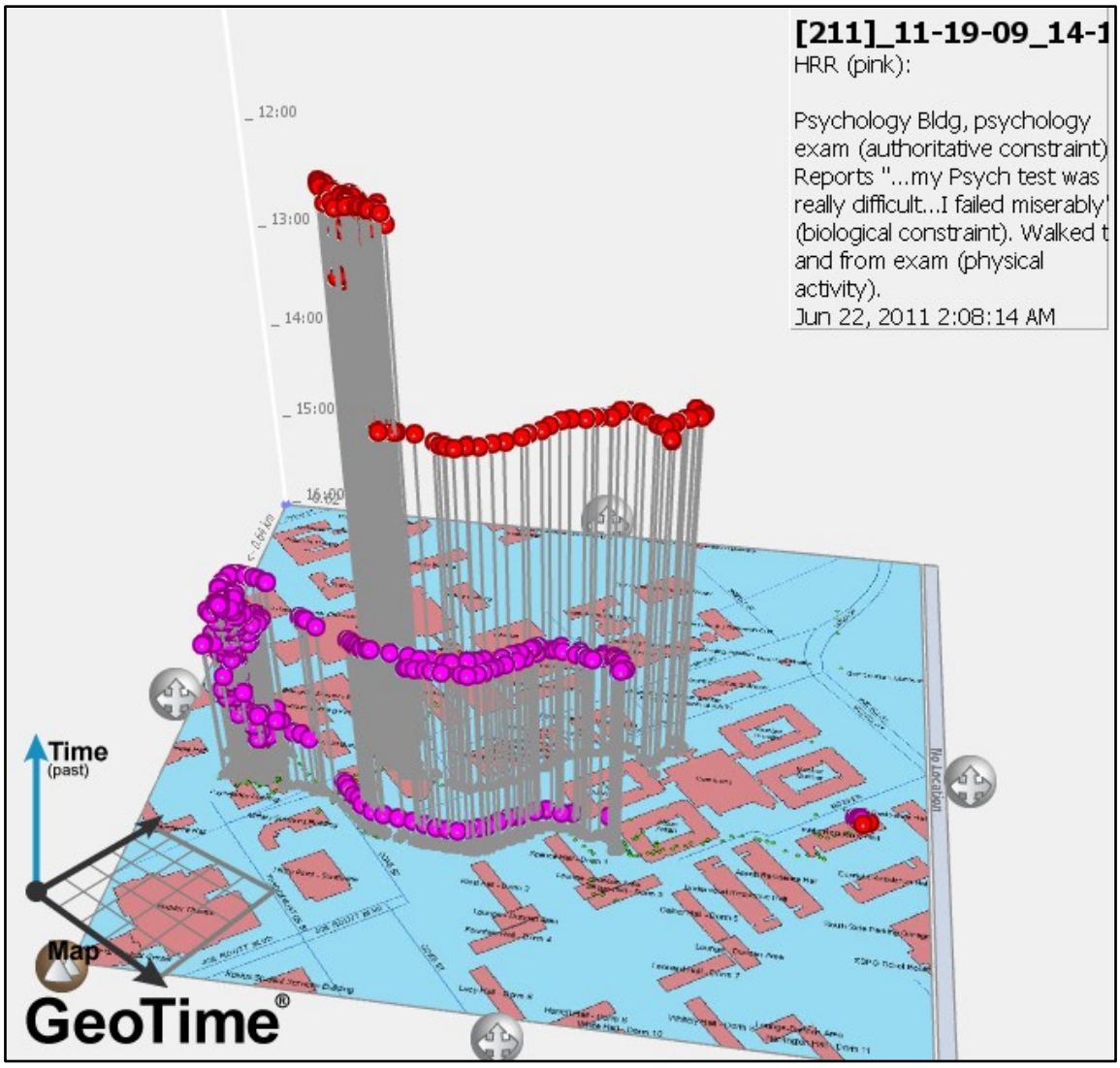



**Figure 55.** Participant 211: map of HRR events (14:00-16:00).
Note: HRR events are in pink and show before, during, and after the participant's Psychology exam.

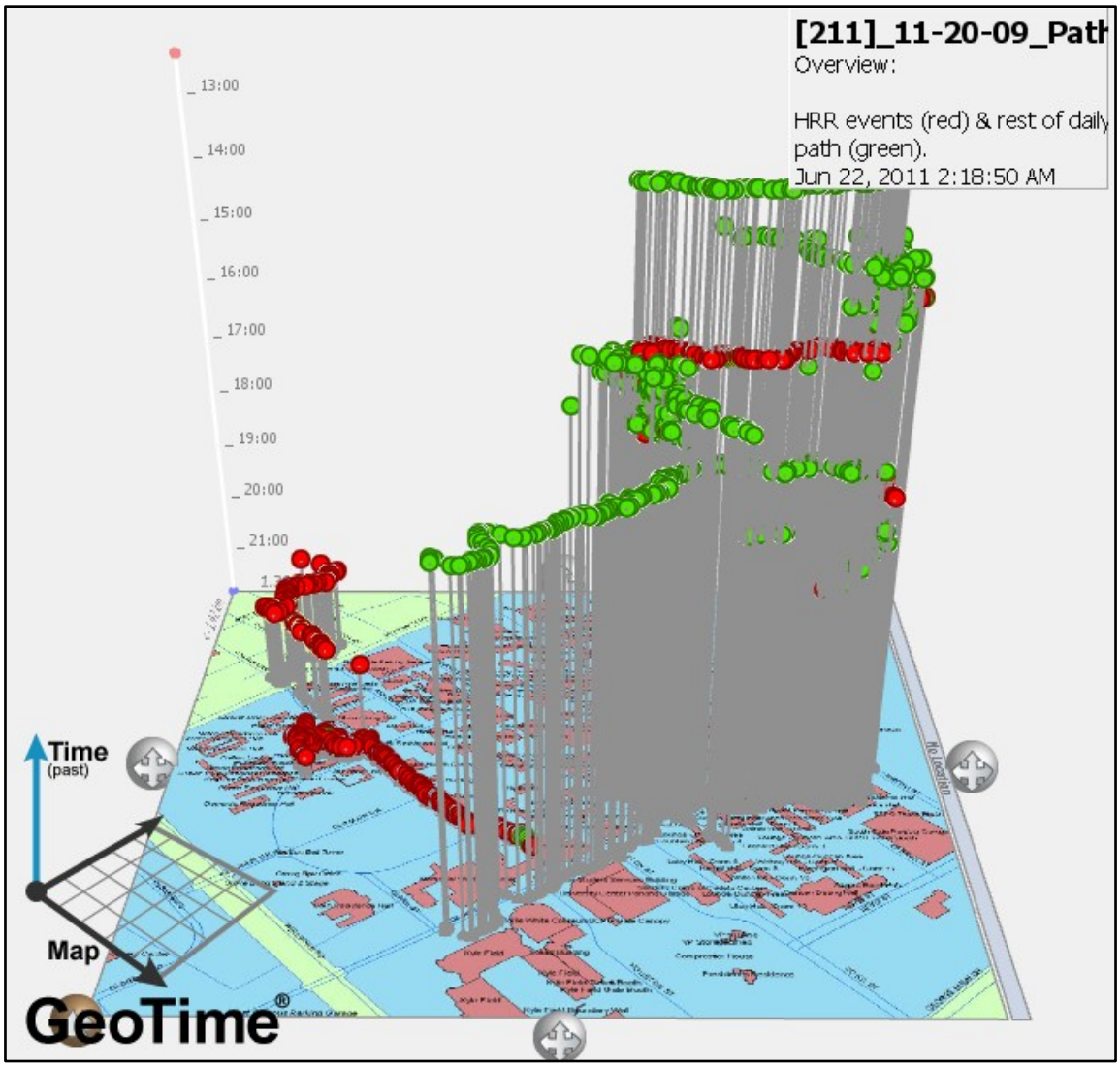



**Figure 56.** Participant 211: map of 11/20/09 daily path.
Note: HRR events are marked in red.

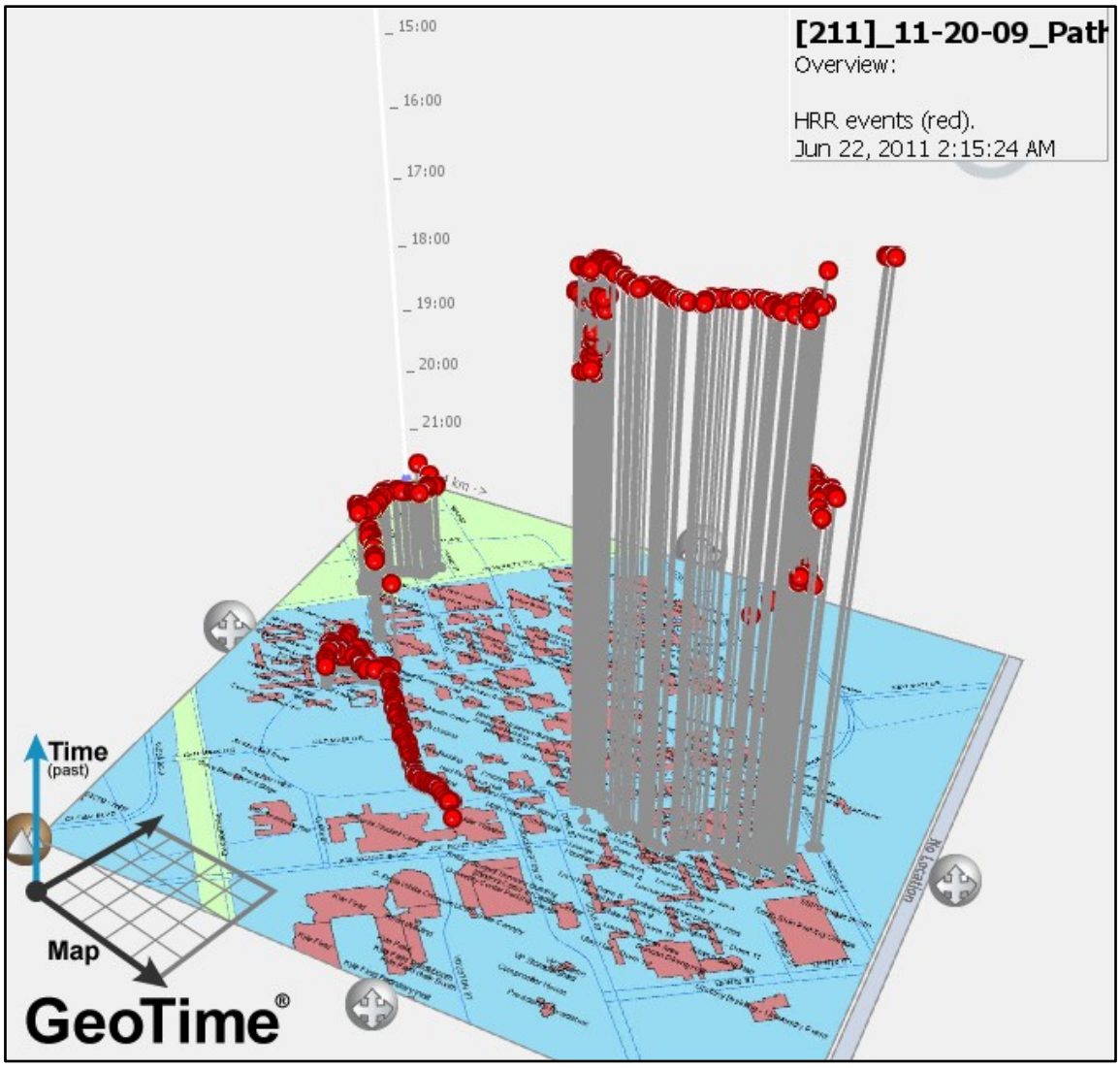



**Figure 57.** Participant 211: map of 11/20/09 logged HRR events.

There were equipment problems in the second monitoring session (Figures 56 and 57), although they were not reported. From 14:00–16:00, during the time that she walked to and took the Biology exam in Heldenfels, there were twenty-two HRR events and three of them lasted a minute or more (Figure 58). More than an hour during this two-hour period zero bpm were recorded, the HR readings were intermittent, and when the monitor did read the HR, it was high. Apparently for some reason the HR sensors were not in constant contact with the participant's skin but she was experiencing stress, so when contact was made it registered high bpm. *"So I'm done with my Bio test and we went and ate dinner at Jin's had a good time"* (Entry 4: 11/23/09 @ 16:53). Approximately three hours later she walks to Jin's in Northgate for dinner (Figure 59). Interpreting the participant's audio entry it would seem that she went to dinner shortly after finishing the Biology exam but this highlights the recall bias difficulty with retrospective accounts.

Between 11:00–13:00, the participant experienced thirteen HRR events (Figures 60, 61, and 62) and three of them lasted a minute or longer. The most pronounced episode ranged from 11:46–12:06 (20 minutes) and corresponds to the badminton tournament at G. Rollie White (Figure 63). *"December 2nd um I had badminton in the morning which was a pretty um it was singles tournament so we it was pretty difficult. And I had to run around a lot because I'm short the tall people always decide to hit the birdie on the opposite side of the court every time so I'm running around so that could of possibly been a reason that my heart rate went up so much [laughing…a bit hard to understand]"* (Entry 5: 12/03/09 @ 21:39).

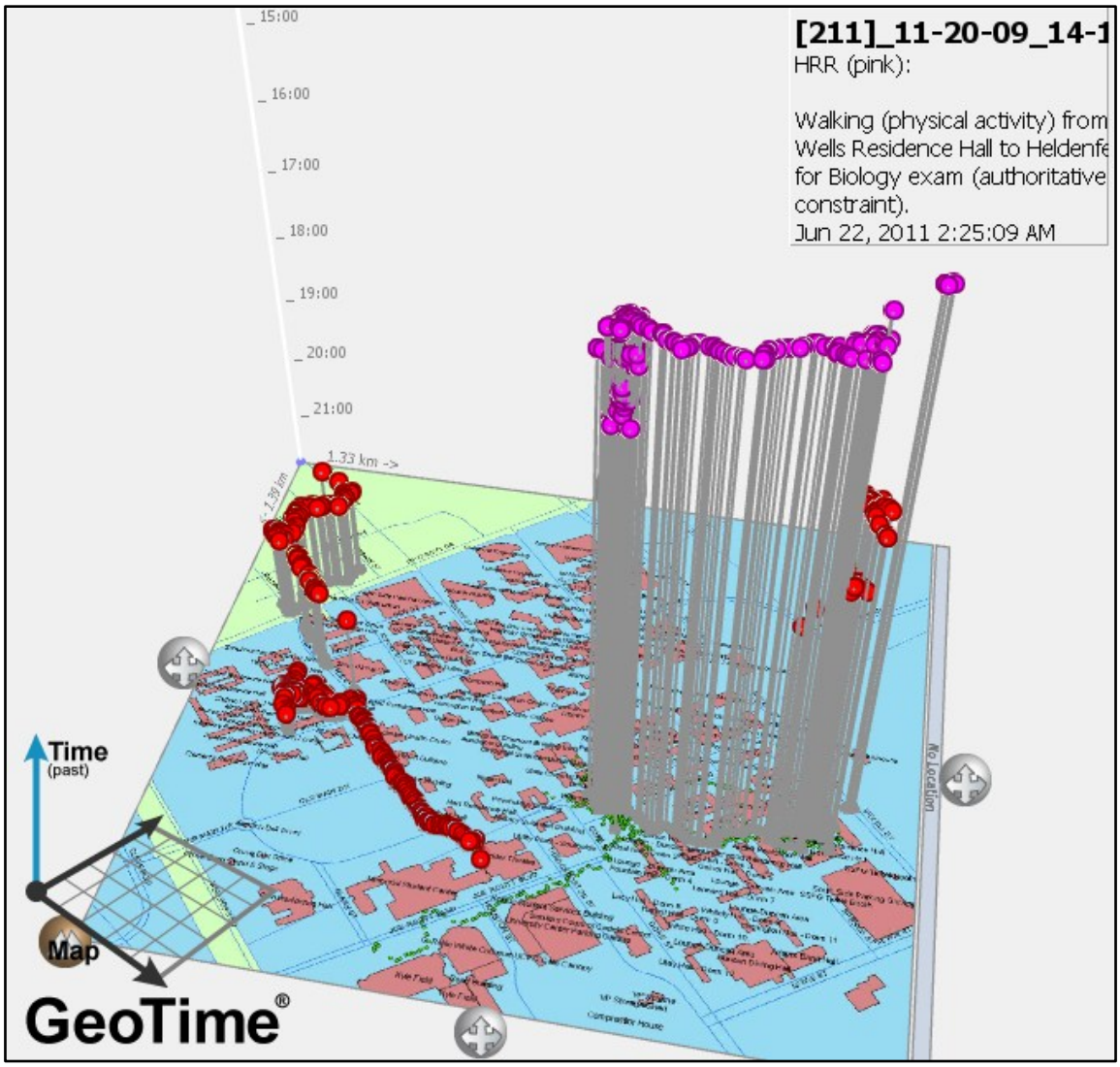



**Figure 58.** Participant 211: map of HRR events (14:00-16:00).
Note: HRR events are in pink and show the participant walking to and taking a Biology exam in Heldenfels.

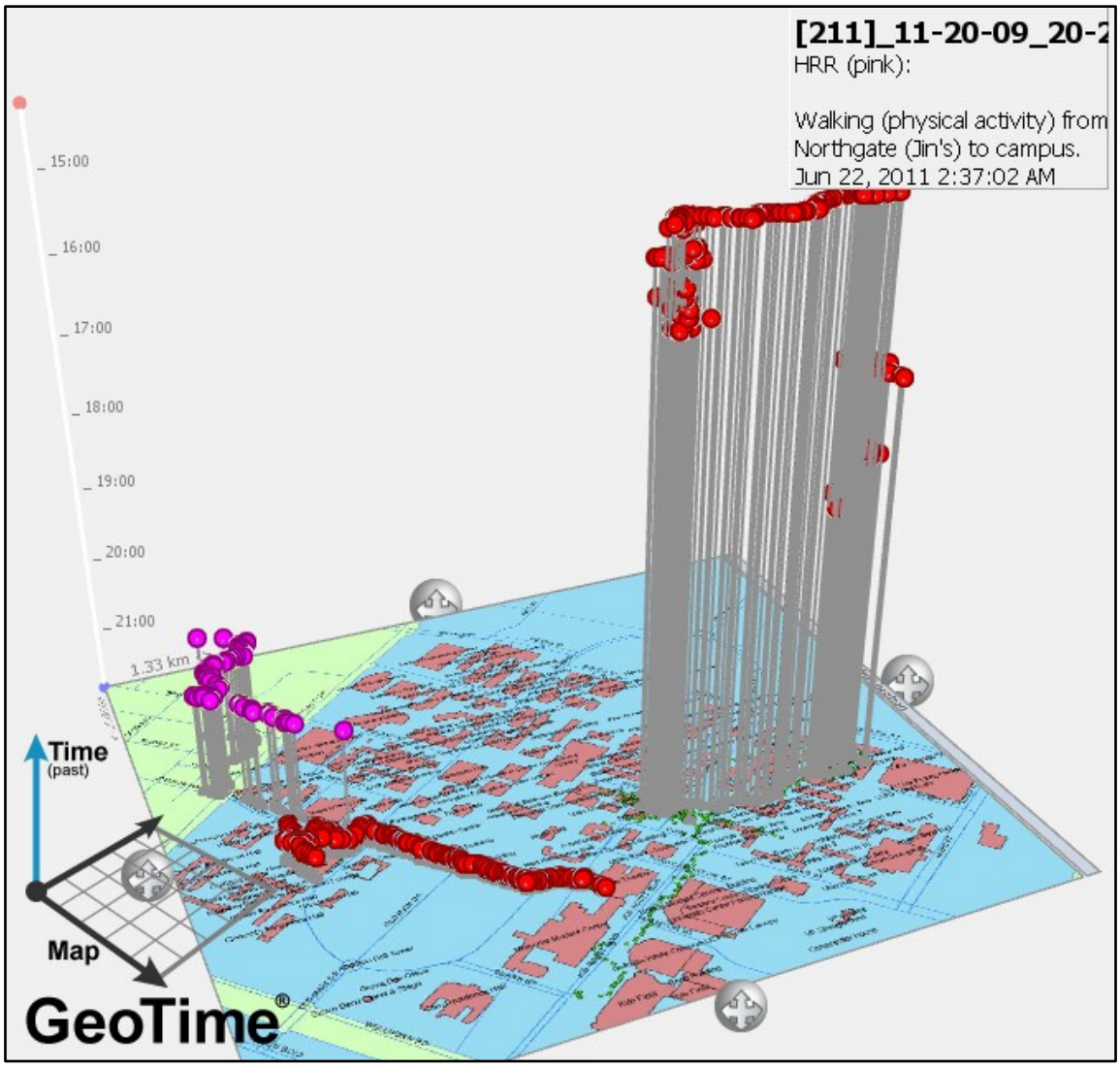



**Figure 59.** Participant 211: map of HRR events (20:00-21:00).
Note: HRR events are in pink and show the participant heading to Jin's Café in Northgate for dinner.

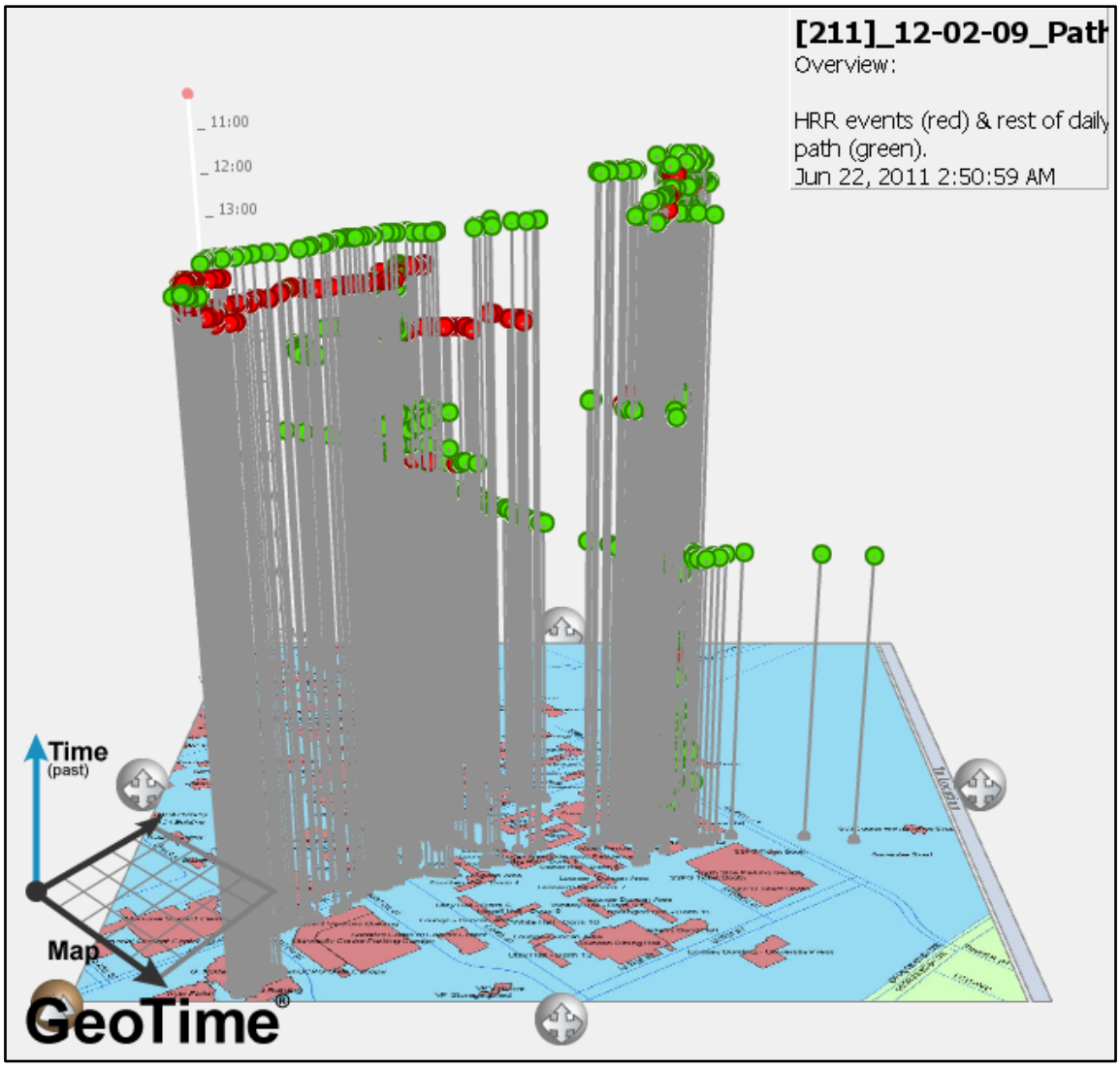



**Figure 60.** Participant 211: map (a) of 12/02/09 daily path.
Note: HRR events are marked in red.

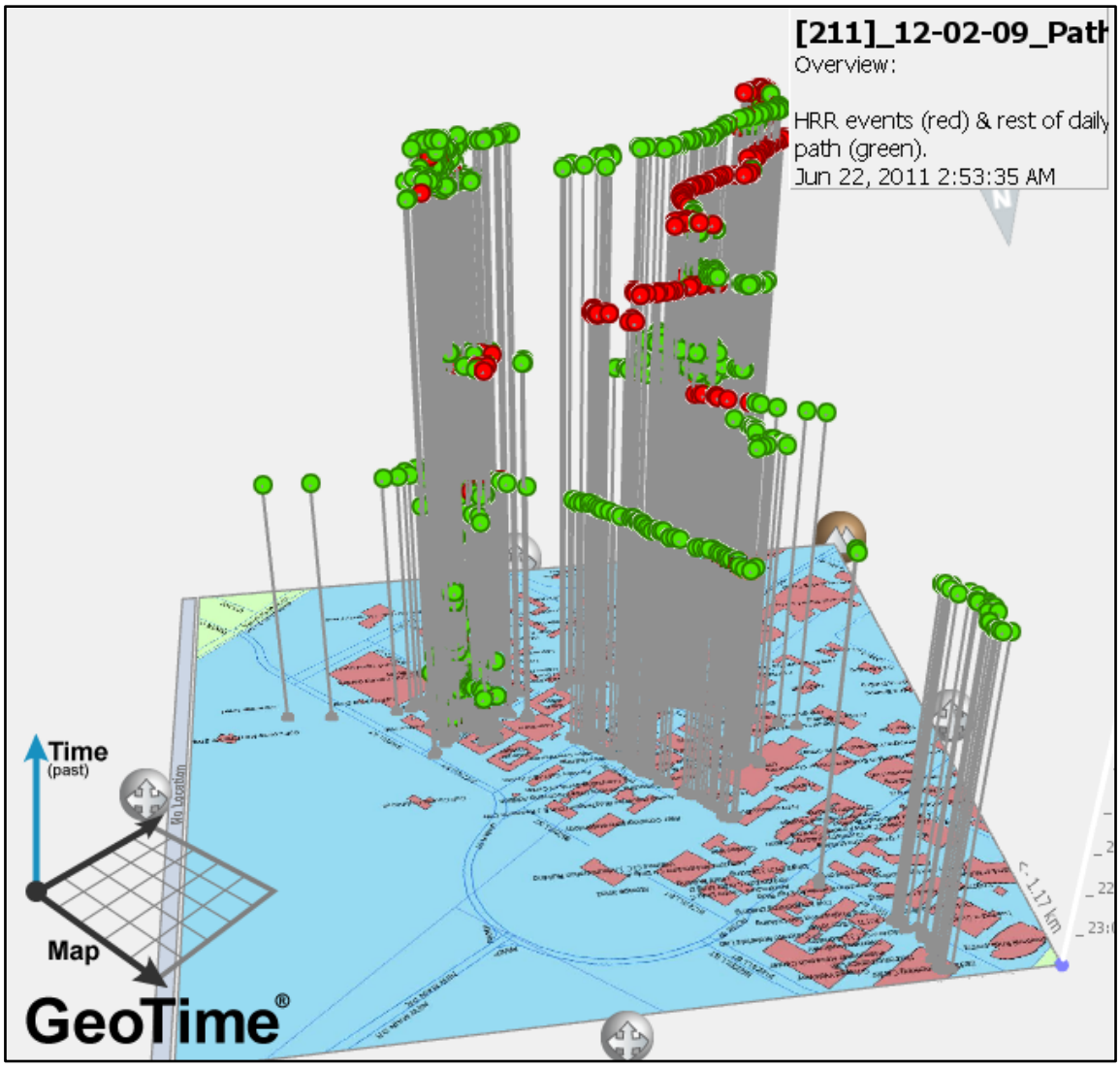



**Figure 61.** Participant 211: map (b) of 12/02/09 daily path.
Note: HRR events are marked in red.

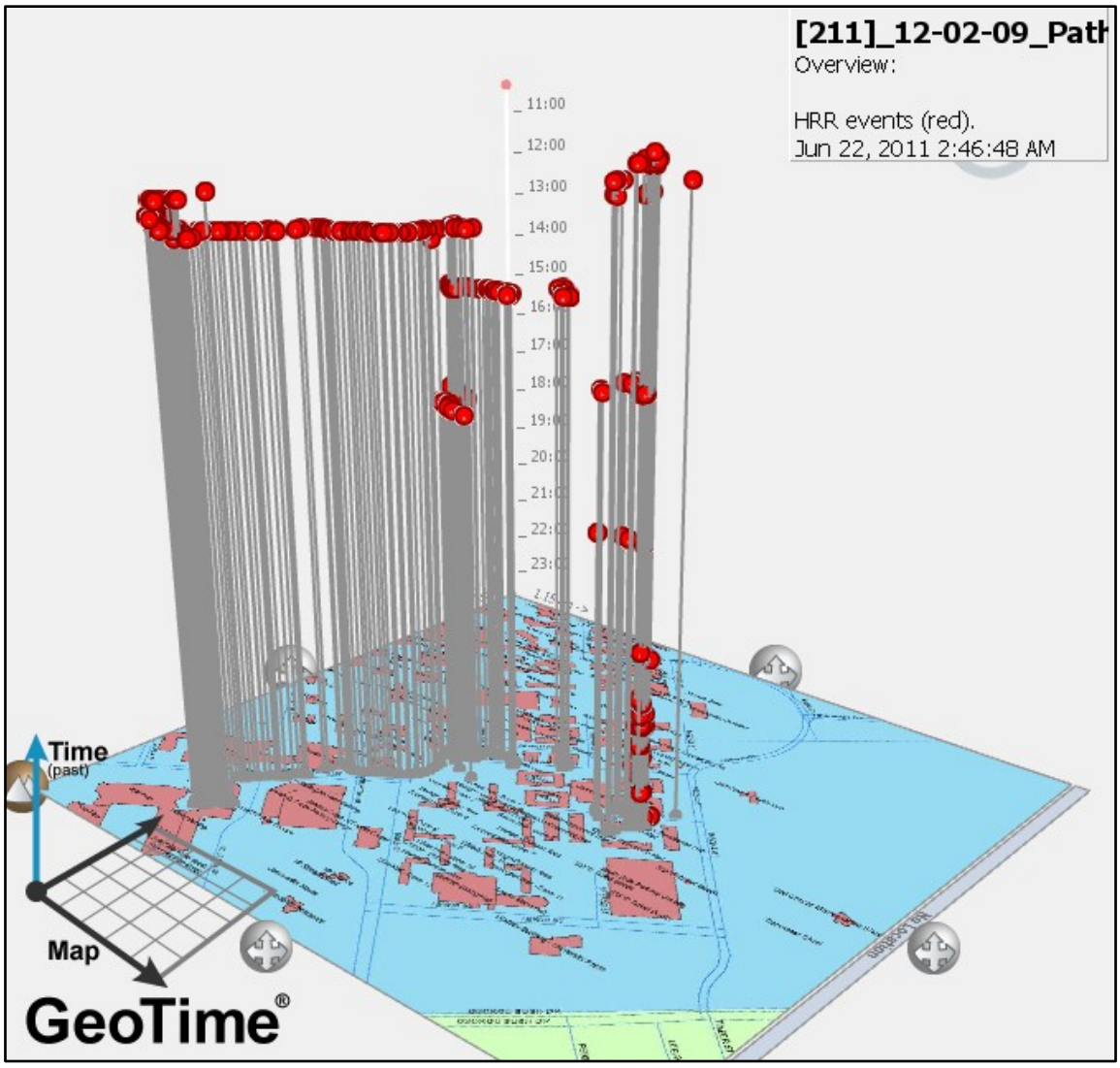



**Figure 62.** Participant 211: map of 12/02/09 logged HRR events.

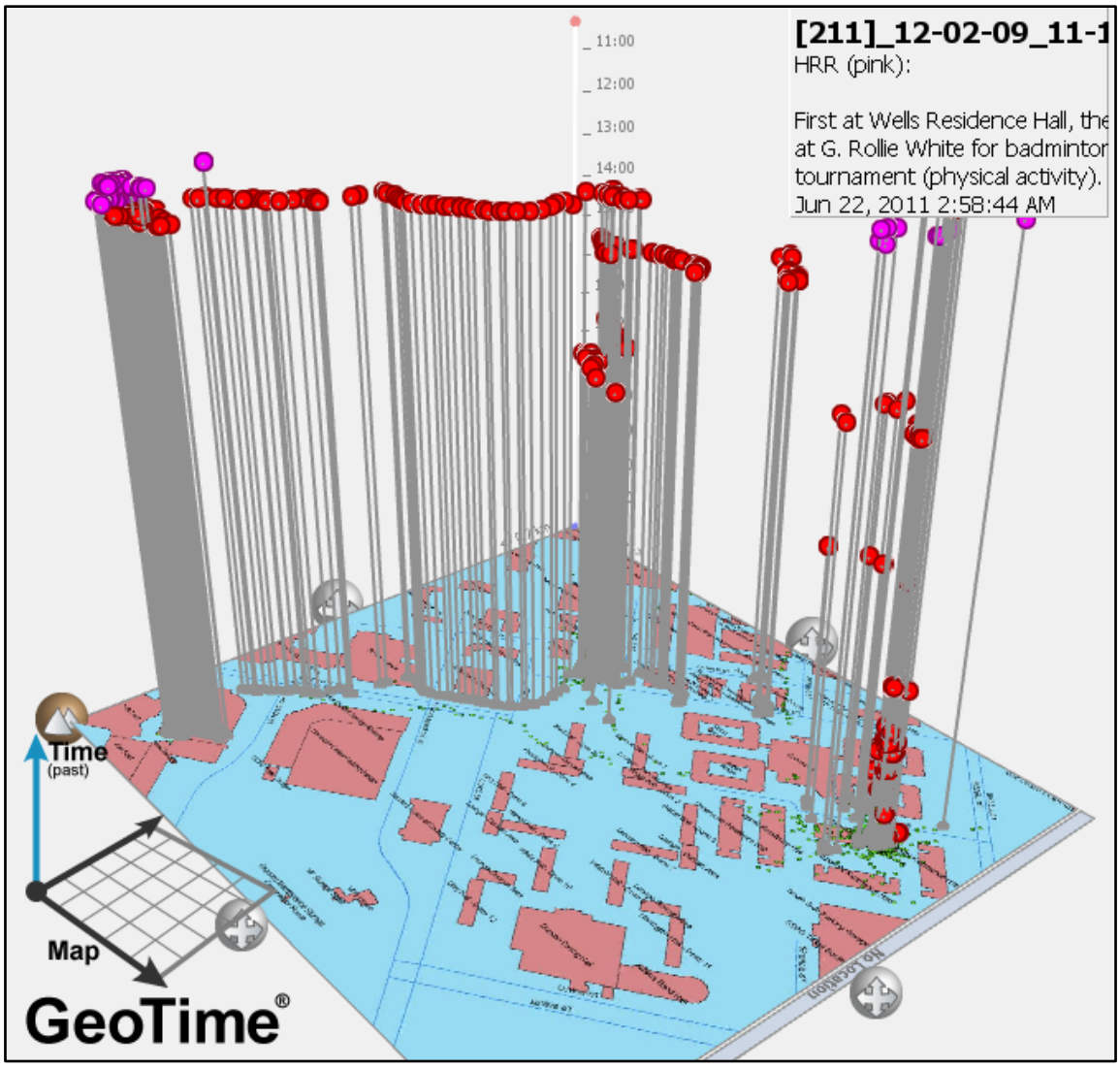



**Figure 63**. Participant 211: map of HRR events (11:00-12:00).
Note: HRR events are in pink and show the participant playing in a badminton tournament at G. Rollie White.

The following entry expresses retrospectively that the Geography exam was difficult and that was a stressor to the participant after the fact (Figure 64). *"Okay so Wednesday evening I had a Geography test. I was extremely frightened um I just took it and it was*

*extremely hard! OMG! It was we were all standing outside discussing the like what we should of put down and what were the right answer was. It was none of us was really sure it was extremely hard um so I'm really stressed out and I'm pretty sure that my heart rate went up. Um yeah"* (Entry 6: 12/03/09 @ 21:41). The monitored spatial and HR data do not make it certain when and where the exam stressor occurred.

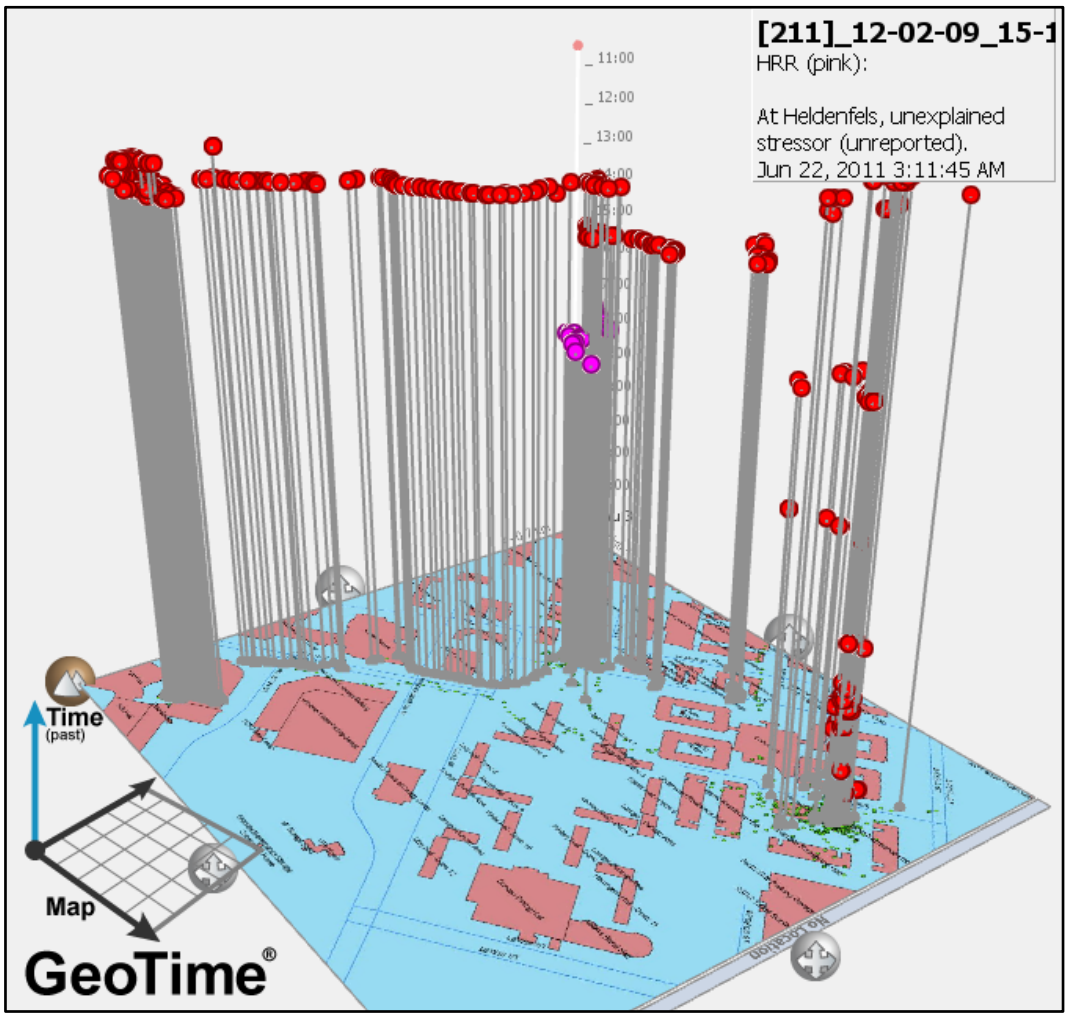



**Figure 64.** Participant 211: map of HRR events (15:00-16:00).
Note: HRR events are in pink and show assumed location of Geography exam.

***Participant 212***

No spatial data were logged by the GPS unit during this participant's monitoring sessions. The HR monitor data for the first session began at 11:34, about 45 minutes after the participant's only reported stressor of the day. *"It's 10:30 in the morning and I'm a little stressed because I have an, a final exam in 15 minutes and I'm running on an hour and half of sleep"* (Entry 1: 11/19/09 @ 18:10). *"Other than my exam this morning today has been a fairly stress free day (pause) but I think I'm finally starting to feel the effects of my lack of sleep"* (Entry 2: 11/19/09 @ 18:16). Her audio diary entries were made 20 minutes after the end of the monitoring session. Overall she experienced twenty-one short HRR events and seven of them lasted a minute or longer.

During the second monitoring session the participant reported stress because of an exam, and discussed her perceived ability limitations and pressure from authority figures. *"It's raining outside and I'm walking to class. I have an exam in 20 minutes and I don't think I studied enough even though I probably could not have studied any more. So the stress I feel is probably a limitation of my own biological ability"* (Entry 3: 11/20/09 @ 17:00). The participant talked about the day's stressors in chronological sequence but they were all recorded several hours retrospective and within a span of 13 minutes (17:00–17:13). *"I'm just walking out of class. I just finished my exam. I don't think I did very well because that was (pause) the hardest exam ever (emphasis). The stress that we all probably feel now is a limitation of our own biological ability cause we studied as hard as we possibly could have, (pause) and also something imposed by an authority figure such as our parents (pause) because in order to do well in the class I*

*had to do well on this exam"* (Entry 4: 11/20/09 @ 17:10). In the following entry she discussed a time of excitement, which similar to the rest of the day's audio described an event that might have registered HRR, but lacking spatial and audio temporal data cannot be accurately linked with the HR logs. *"I just got my grade back from my Chemistry Lab final exam that I took yesterday. And, I did really well. So this could definitely be characterized as a period of excitement"* (Entry 5: 11/20/09 @ 17:13). The monitoring session logs 18 out of 116 HRR events lasting 1 minute or more. Additionally, three episodes were 10 minutes or longer in duration, from 16:11–16:21 (10 minutes), 16:23–16:39 (16 minutes), and 18:35–18:50 (15 minutes).

The participant specifically pinpointed times while discussing this stressor related to a Geography exam. *"It's 3 o'clock Monday and I have my Geography exam in an hour and (pause) I don't think I studied enough (sigh) and I'm freaking out. This stress is probably caused by a biological ability; just me not being able to study any harder"* (Entry 7: 11/24/09 00:04). She experienced fifty-one HRR events during the time between 15:00–18:00 and six of them lasted a minute or longer. Four of the longer HRR events ranging from 15:51–16:10 (19 minutes), 16:44–17:04 (20 minutes), and 17:12–17:59 (47 minutes) correspond with the reported Geography exam stressor.

***Participant 213***

In the first monitoring session the participant noted the period that she spent in dance class (physical activity). *"It is 2:20pm on November 19th and I just walked from the library to the dance building and I'm about to start a dance class that will go for about an hour and a half"* (Entry 3: 11/19/09 @ 14:20). During the time span from 14:00–16:00 she experienced fifty-five HRR episodes, which are attributed to the physical activity associated with dance class. Out of the ten HRR events that last a minute or more, two were 10 minutes or longer, 13:59–14:09 (10 minutes) and 14:55–15:06 (11 minutes). *"It is 3:58pm and I just got home from dance um I'm going to rest for a while and then I'll be going back from 4:30 to 7pm"* (Entry 4: 11/19/09 @ 15:58). When the participant goes back for another dance class, between 16:30–19:00, there are only about 30 minutes left in the session. From 16:30-16:38, three HRR events were logged, two lasting longer than a minute.

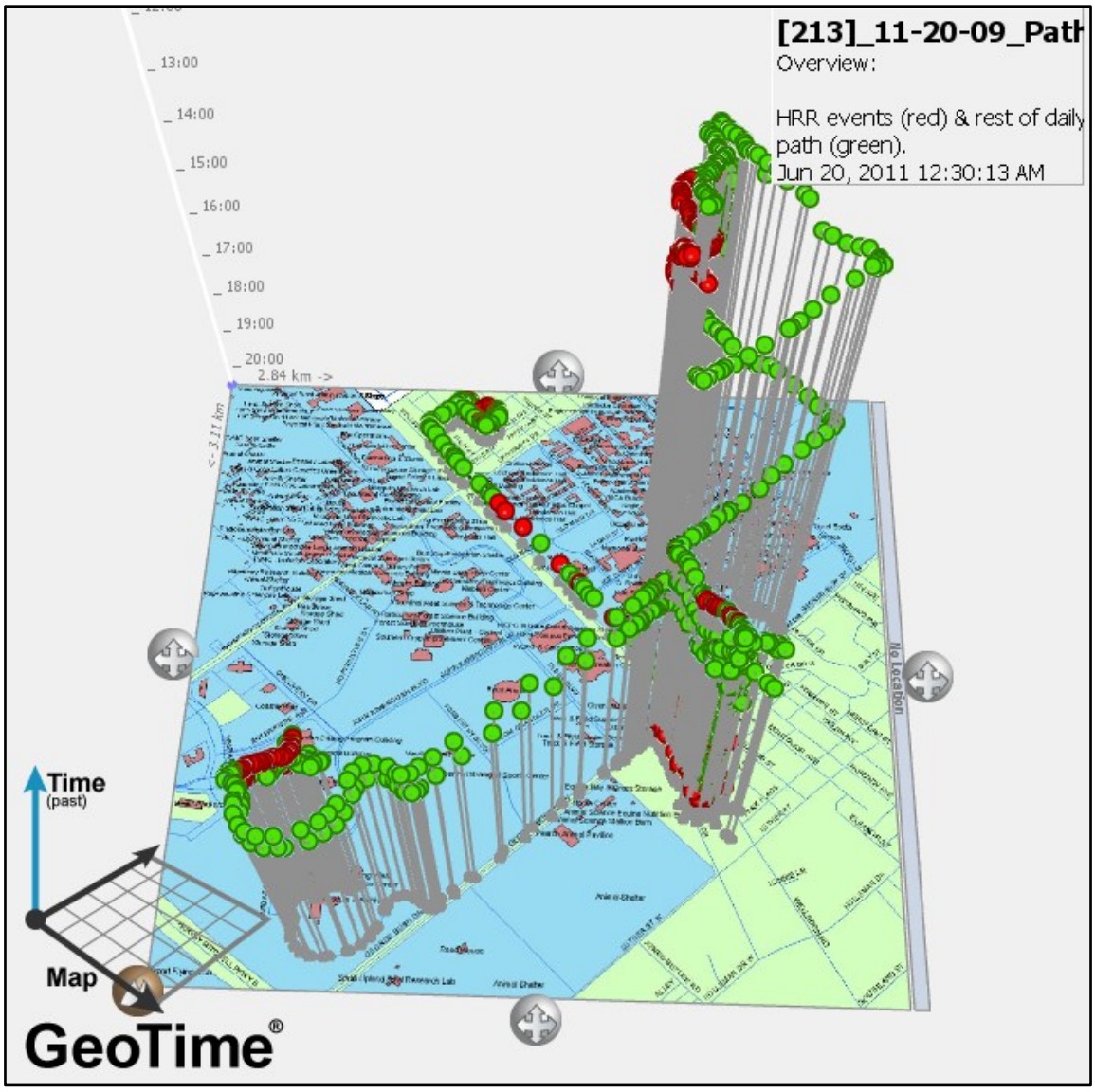



**Figure 65.** Participant 213: map of 11/20/09 daily path.
Note: HRR events are marked in red.

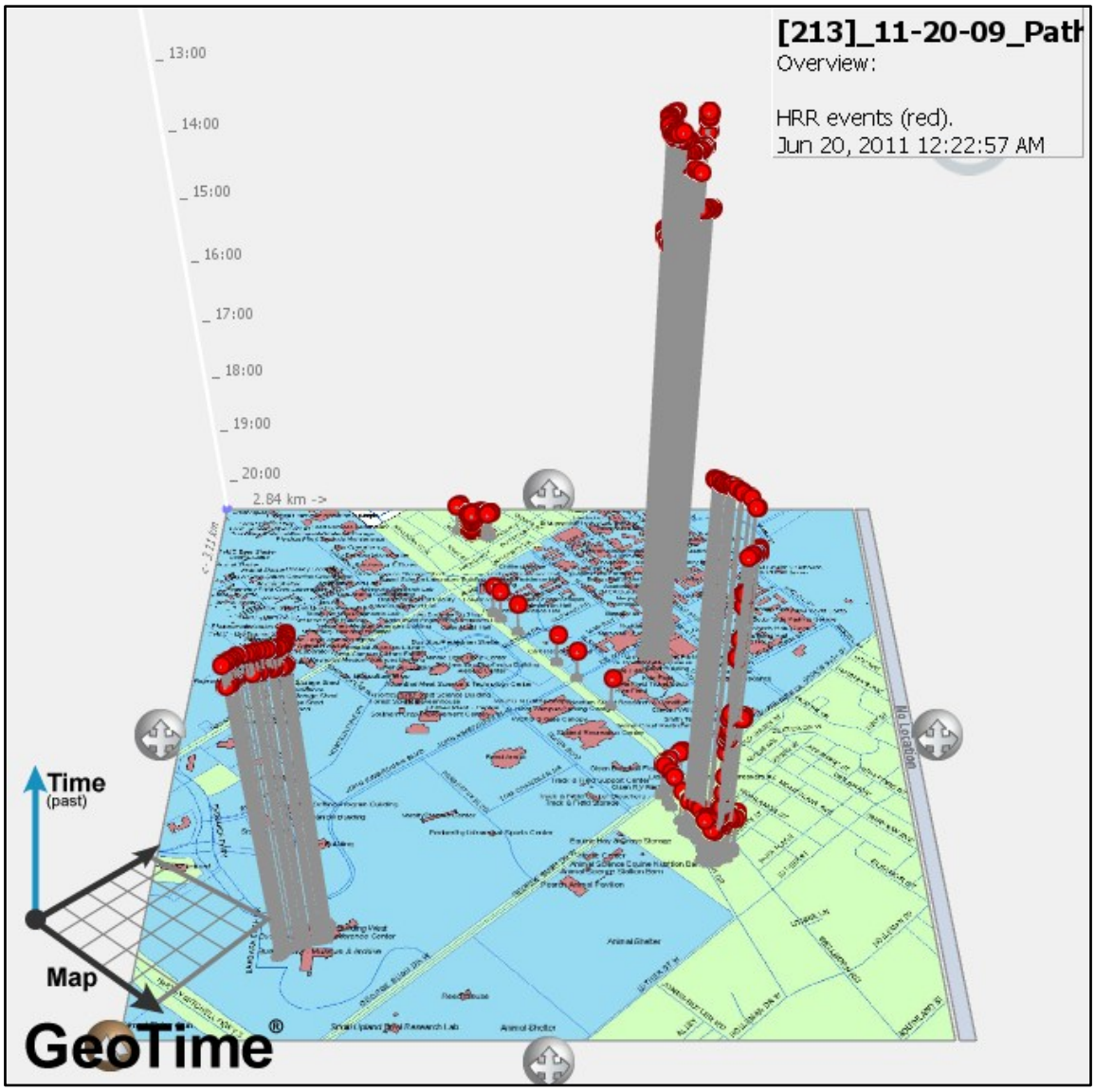



**Figure 66.** Participant 213: map of 11/20/09 logged HRR events.

During the second monitoring session, from 10:55–20:31, is the only time that the data are recorded from all three sources, GPS (spatial), HR monitor (bpm), and audio diary (Figures 65 and 66). Although she did venture out, the location data shows that the participant spent the majority of her day at home, presumably studying for exams as reported. *"But today I've spent most of my day um studying because I have four tests between Monday and Tuesday of next week. So that is stressing me out a lot. Um I haven't been very active today. Um I have had coffee and that probably will the caffeine will probably make my heart rate go up"* (Entry 5: 11/20/09 @ 18:13). In her diary entry the participant attributed stress to looming exams (authoritative constraint) and having caffeine (a stimulant) but she didn't pinpoint these activities temporally or spatially (Figure 67). Overall she experienced eighty-five brief HRR events, with only two that lasted longer than 5 minutes (thirteen logged at a minute or more).

In the approximately fourteen and a half hours between 8:09–22:27 (Tuesday 11/24/09), the third monitoring session, the participant experienced a total of 330 HRR events. About 25 percent (61) of the episodes lasted 1 minute or longer. She provided no explanatory information, except that in a previous entry she noted that she had four exams between Monday and Tuesday and no spatial reference was logged.

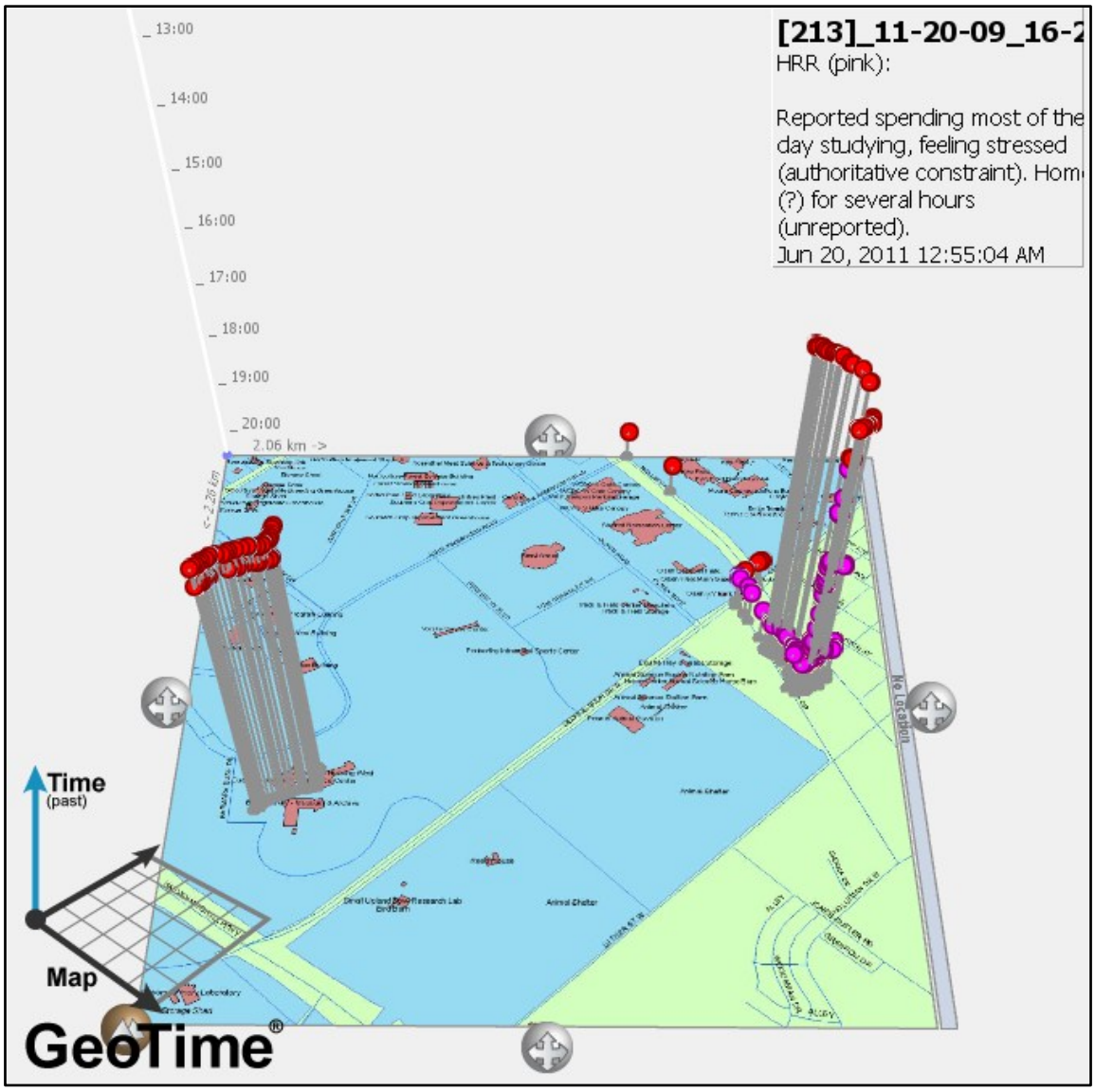



**Figure 67.** Participant 213: map of HRR events (16:00-20:00).
Note: HRR events are in pink.

The participant experienced five sustained HRR events, three of them lasting between 17 and 23 minutes, and two persisted beyond 45 minutes. It's possible that these long events were associated with physical activity such as dance class or heightened stress related to exams.

***Participant 215***

The data for this participant consist of HR (bpm) and audio entries; spatial data were not logged. During the participant's first monitoring session he designated a period in the evening when he was studying at his apartment. *The time is 10:35 and I'm here in my apartment. And I'm kinda stressed out because I have a test next Monday and I've been studying for 45 minutes"* (Entry 1: 11/19/09 @ 22:36). He reported preparing for an exam on Monday as a stressor. Within the 45 minutes, 21:50–22:35, the participant experienced nineteen HRR events and one lasted more than a minute. Overall, between 18:47–00:27, he experienced eighty-two brief HRR episodes, with four lasting 1 minute or more.

In the period spanning 30 minutes before the participant met with his advisor (9:30) to when he made this entry, the participant had thirteen short HRR events. *"It's 10:57 and like an hour ago I was talking with an advisor and was kind of stressed out because I don't know what classes to take next year and I was trying to do my schedule"* (Entry 3: 11/20/09 @ 13:58). He experienced two HRR episodes that last more than 1 minute, the first corresponding to the reported stressor of discussion of next year's schedule with an advisor. It lasted from 9:52 to 9:56 (4 minutes). Later in the day, between 16:00–

18:30, he reported cleaning his room, physical activity that may register as HRR. *"It's 4:01 and I'm here at my apartment and at this time I am doing my laundry and I have a lot of things to do right now"* (Entry 4: 11/20/09 @ 16:01). The participant also stated that he had "…*a lot of things to do right now*," which indicates a sense of time pressure. Between 15:56–18:27 while cleaning his apartment and dealing with the pressure of having many tasks to accomplish in a short time (biological constraint), the participant experienced twenty-four HRR events. Nine of the events were a minute or more in duration and three of the nine span 29–43 minutes. *"I'm here in my apartment and ten minutes ago I just finished my laundry and cleaned my room"* (Entry 5: 11/20/09 @ 18:35). The participant did experience other HRR episodes in this monitoring session (8:26–18:27) but there is no spatial data or other diary accounts to help provide explanations.

In the final monitoring session, from 8:53–18:52, the participant reported several encountered stressors related to academics. *"The time is 11:23 and I'm here in my apartment. And at this time I'm cramming for a quiz that I have in two hours. And the particular constraint associated with my stress is 'B' a limitation of my own biological ability"* (Entry 6: 11/23/09 @ 11:24).

From 11:00, immediately before he reported cramming for a quiz, until 17:00, a few minutes after finishing an exam, the participant experienced 170 HRR events. *"It is 1:40 and at this time I'm running for my class because I will be late <can hear the background noise of vehicles>"* (Entry 7: 11/23/09 @ 13:40). Thirty of the HRR episodes lasted a minute or longer and ten of those thirty last 5 minutes or more, including an event from 13:31–13:50 (19 minutes) that corresponds with the participant being late to take a quiz. "*It is 2:20 and at this time I am here school and I'm kind of stressed out because in two hours I have a test and have to study right now"* (Entry 8: 11/23/09 @ 14:21). Another long HRR event, from 14:09–14:36 (27 minutes), corresponds to the entry discussing being stressed due to studying for an exam. Additionally, during the exam he experienced several HRR events, including one from 16:10–16:25 (15 minutes). *"It's ?:58 and I just I'm here at school. I just finished my test and right now I'm just walking toward my apartments"* (Entry 9: 11/23/09 @ 16:58).

***Participant 216***

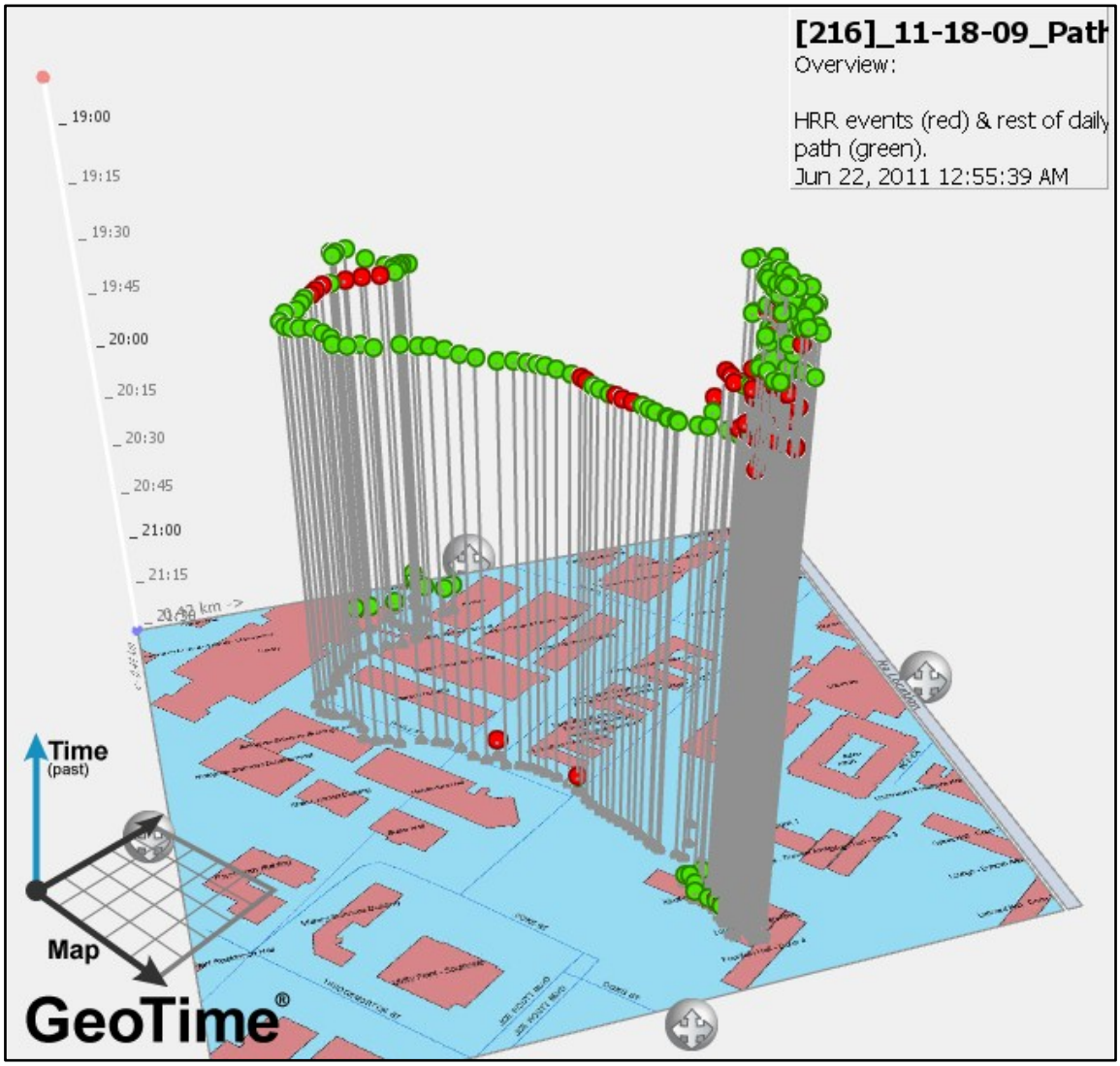



**Figure 68.** Participant 216: map of 11/18/09 daily path.
Note: HRR events are marked in red.

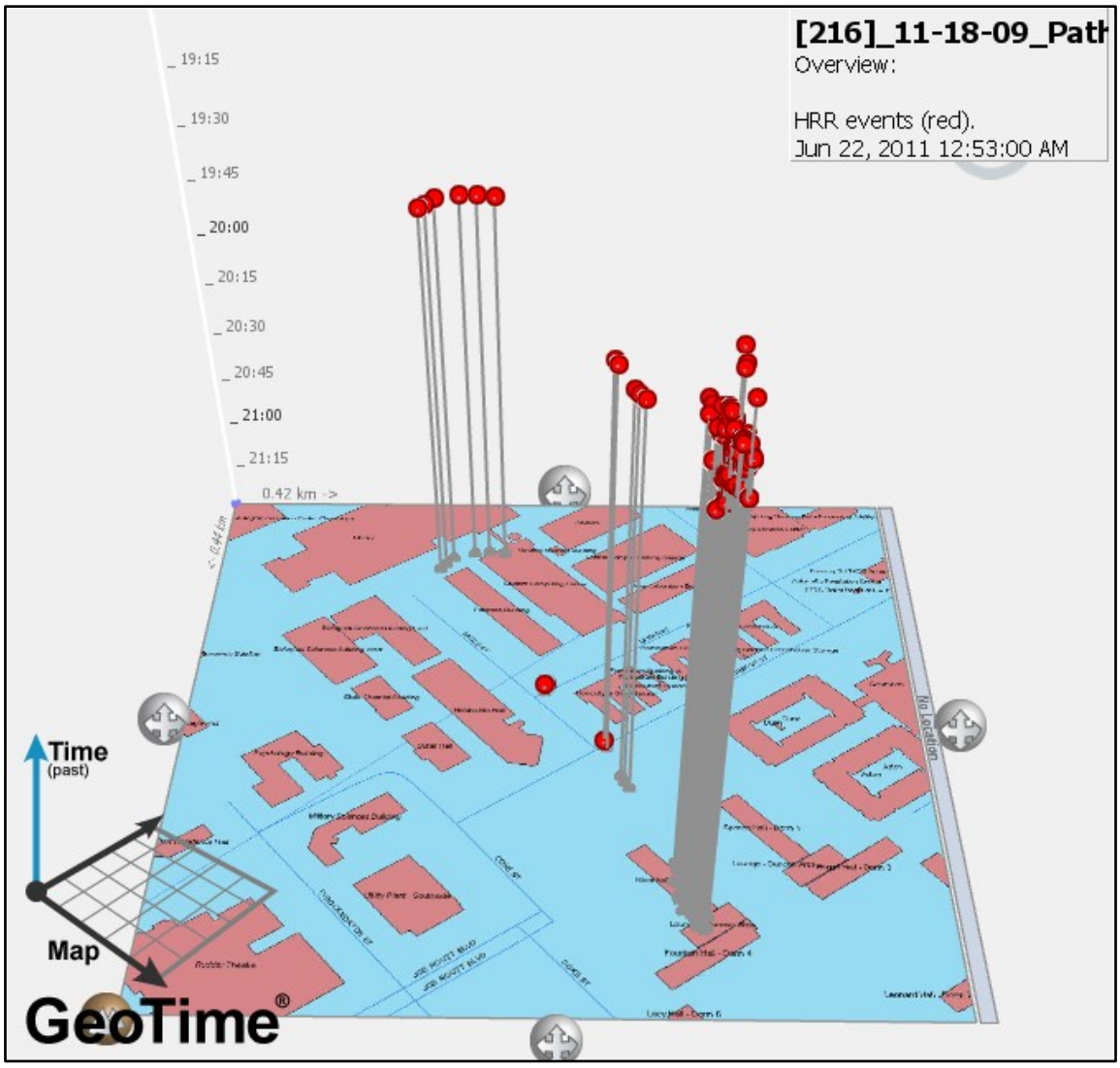



**Figure 69.** Participant 216: map of 11/18/09 logged HRR events.

The participant's first monitoring session, from 17:24–21:30, was the most complete regarding the logging of HR data but she did not record any diary entries on 11/18/09 to provide explanations (Figures 68, 69, and 70). During the session she experienced twenty HRR events and four of them last 1 minute or longer. Three of the episodes lasted 3 to 10 minutes and could be associated with working out, which she reported doing in the dorm the next day, studying, or a unrelated activity. *"Been working out some heart rate might be a little fast"* (Entry 2: 11/19/09 @ 14:30).

The participant started her second monitoring session (Figures 71 and 72) approximately 30 minutes before reporting the possibility of stress during the Chemistry lab exam. *"I'm have a Chemistry lab final right now so my heart rate might go up"* (Entry 1: 11/19/09 @ 10:51). Nine brief HRR events were logged between 10:30–12:00, covering the period corresponding to the Chemistry lab exam (Figure 73). Although the participant did not report equipment problems, it is apparent from bpm logging zero that the HR sensors were not making sufficient skin contact for much of the second and third monitoring sessions. Later in the day she reported a possible stressor associated with "having" to study for a Biology exam (Figure 74), which indicates authoritative constraint. *"<cleared throat> Having to study…Biology test my in case my heart rate <unclear…seems like the recording faded in and out, missing words>"* (Entry 3: 11/19/09 @ 18:53). No HR data were recorded around the time of 18:53; therefore, the logs cannot support or refute an HRR event related to studying. The only stressor indications are three brief HRR events between 17:33–18:12, which occurred in her dorm but could be completely unrelated.

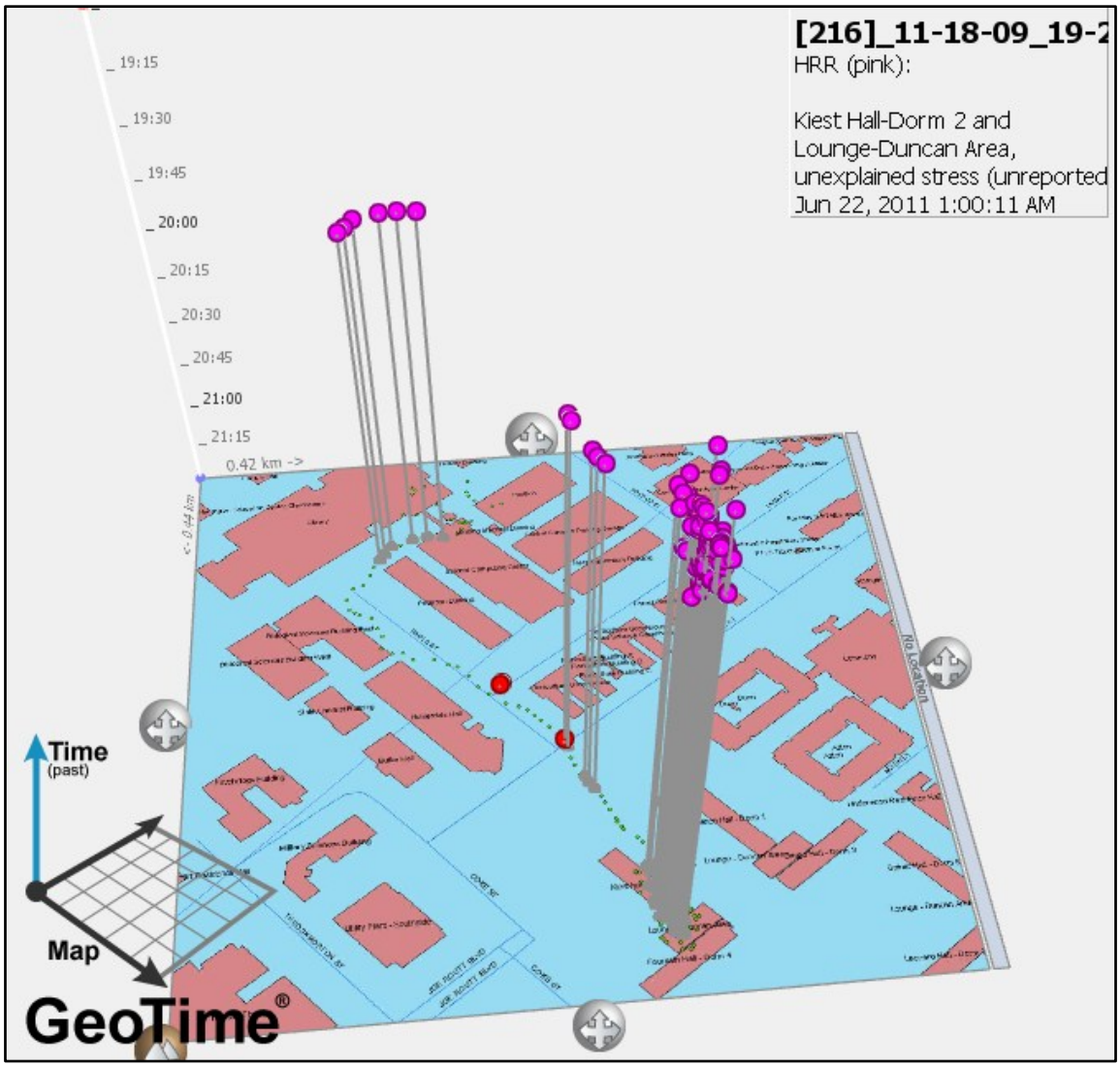



**Figure 70.** Participant 216: map of HRR events (19:00-20:00).
Note: HRR events are in pink and show unreported HRR occurrences in the participant's dorm.

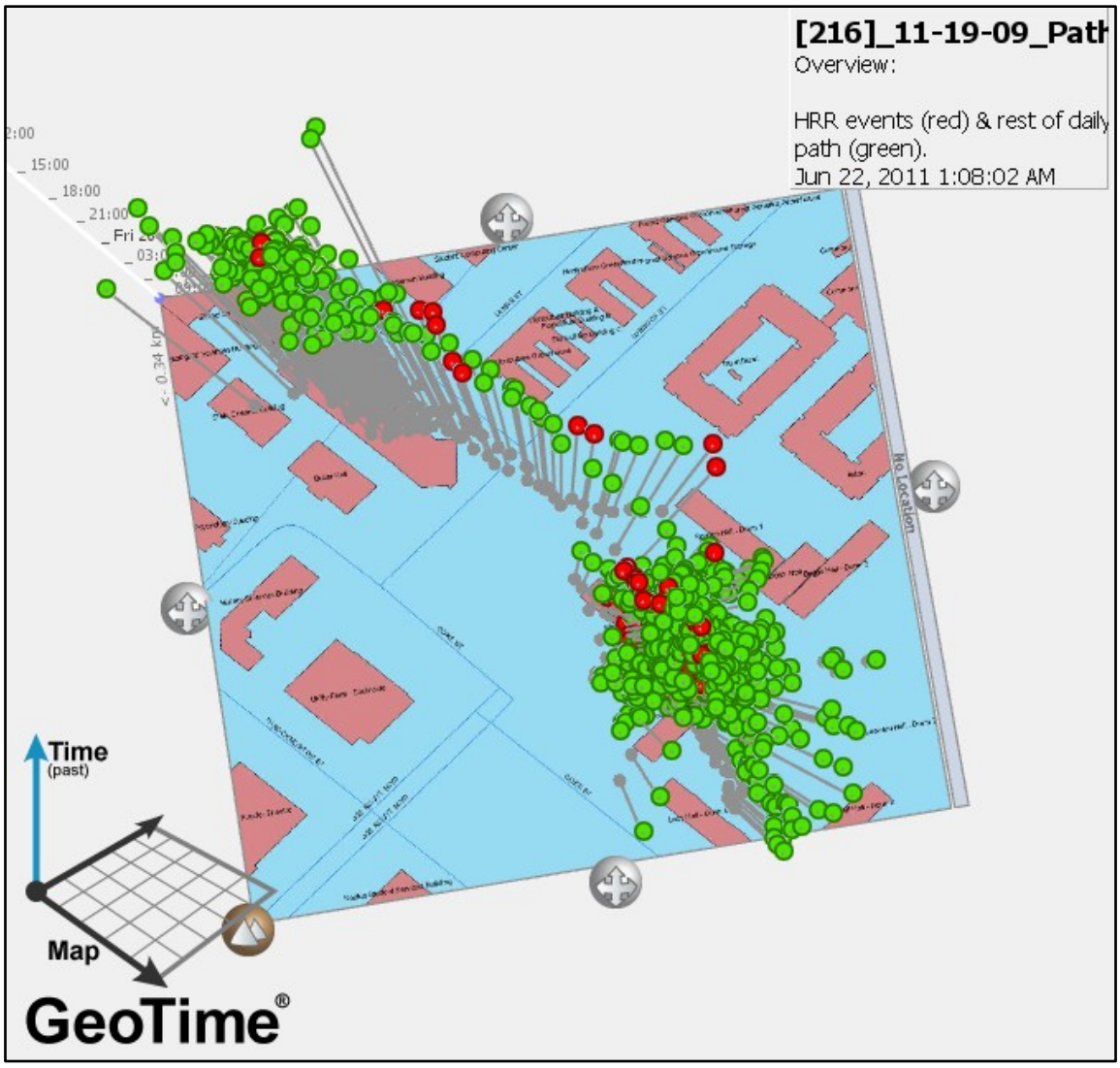



**Figure 71.** Participant 216: map of 11/19/09 daily path.
Note: HRR events are marked in red.

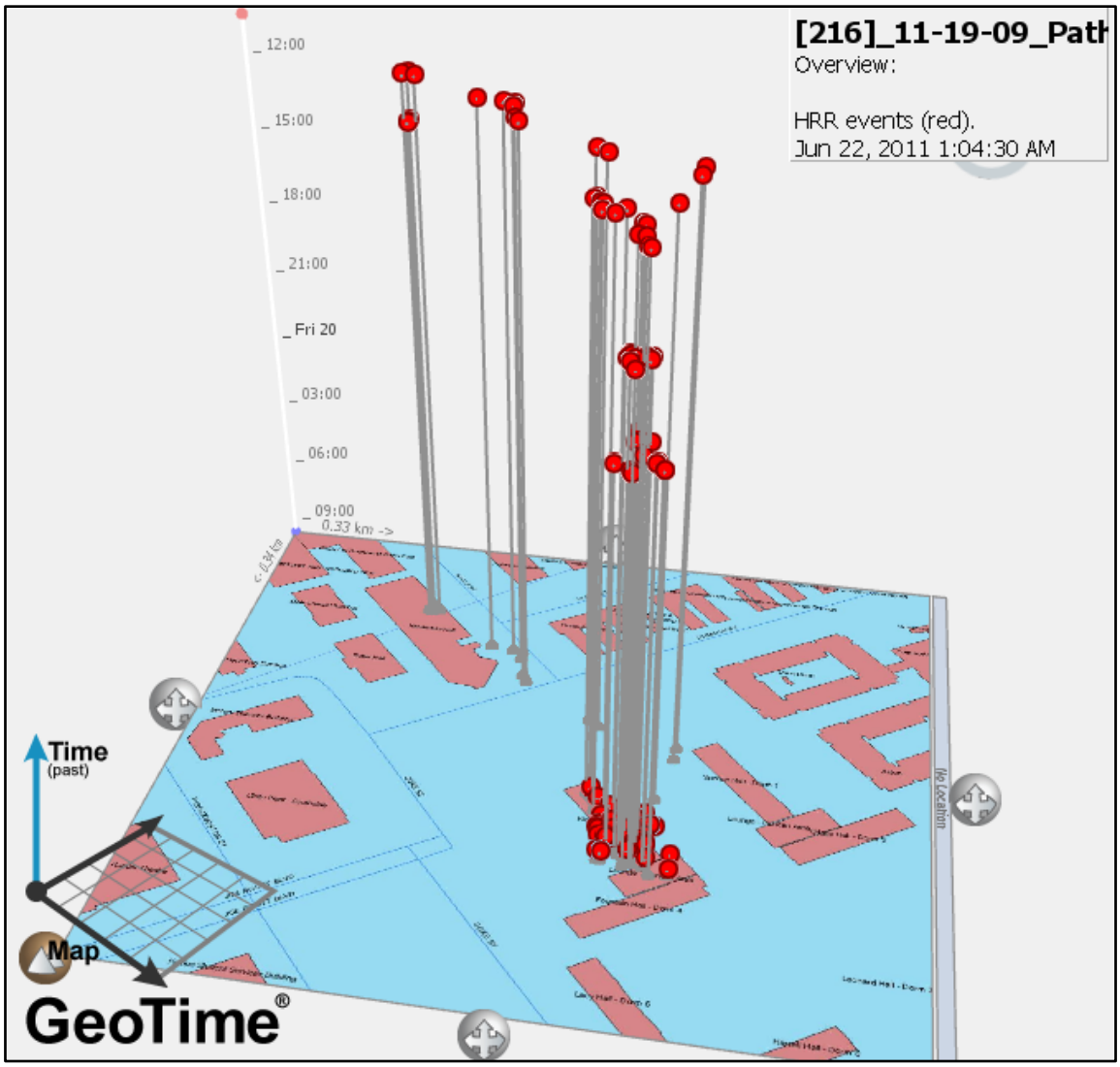



**Figure 72.** Participant 216: map of 11/19/09 logged HRR events.

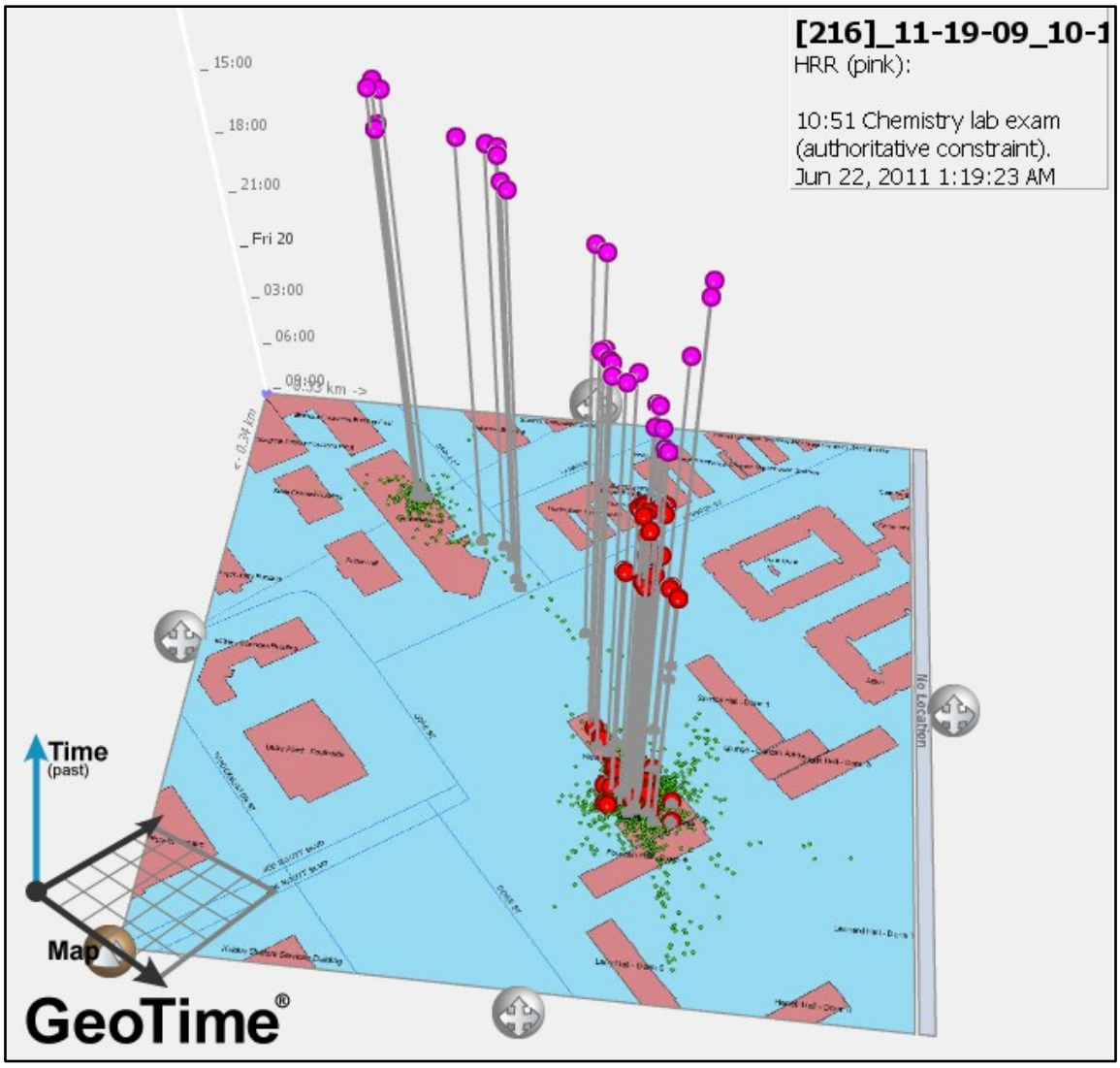



**Figure 73.** Participant 216: map of HRR events (10:00-13:00).
Note: HRR events are in pink and show some of HR elevation associated with the participant's Chemistry exam.

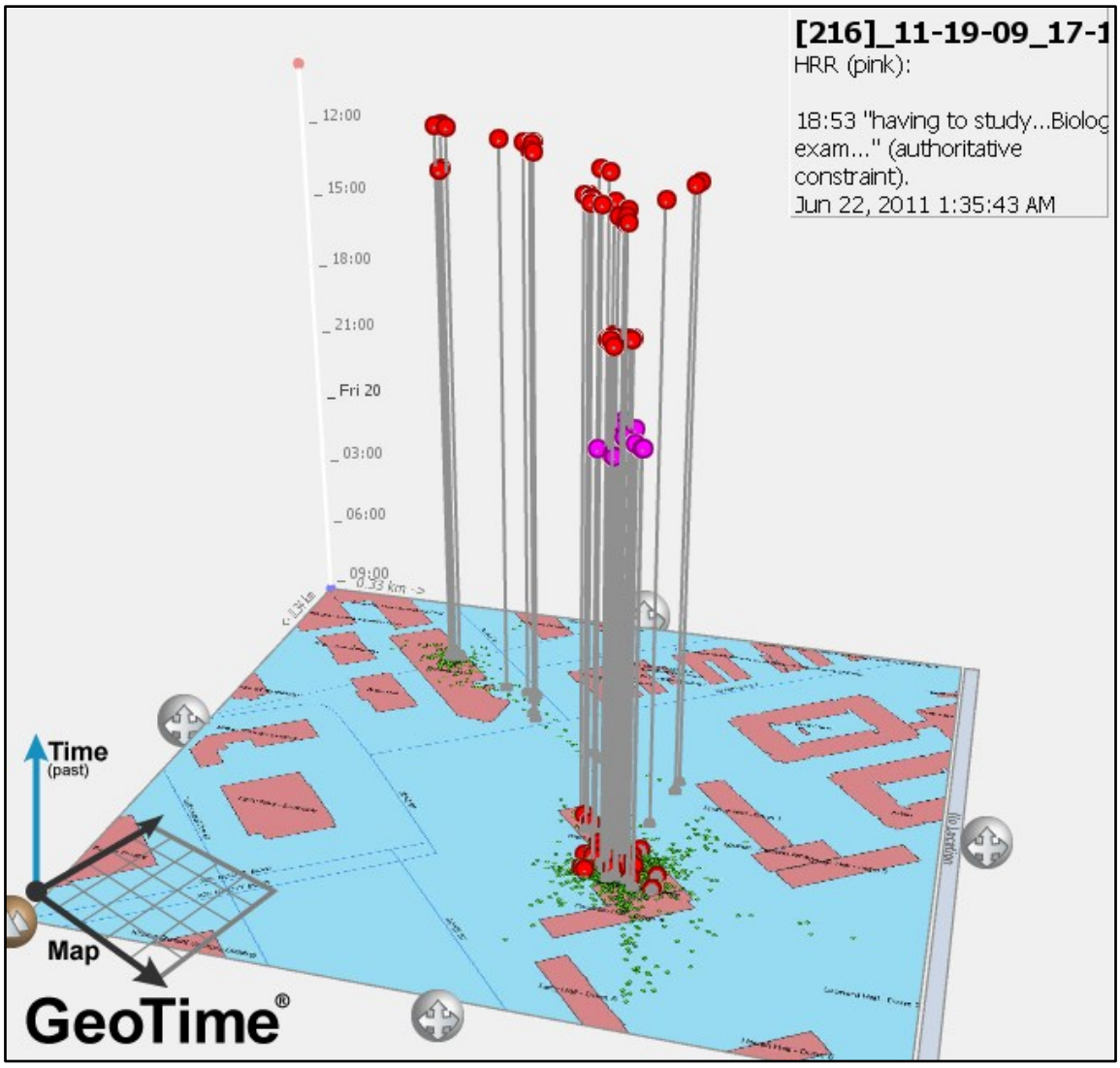



**Figure 74.** Participant 216: map (a) of HRR events.
Note: HRR events are in pink and show brief HR increases in the participant's dorm in the hour and a half before an audio entry reporting studying.

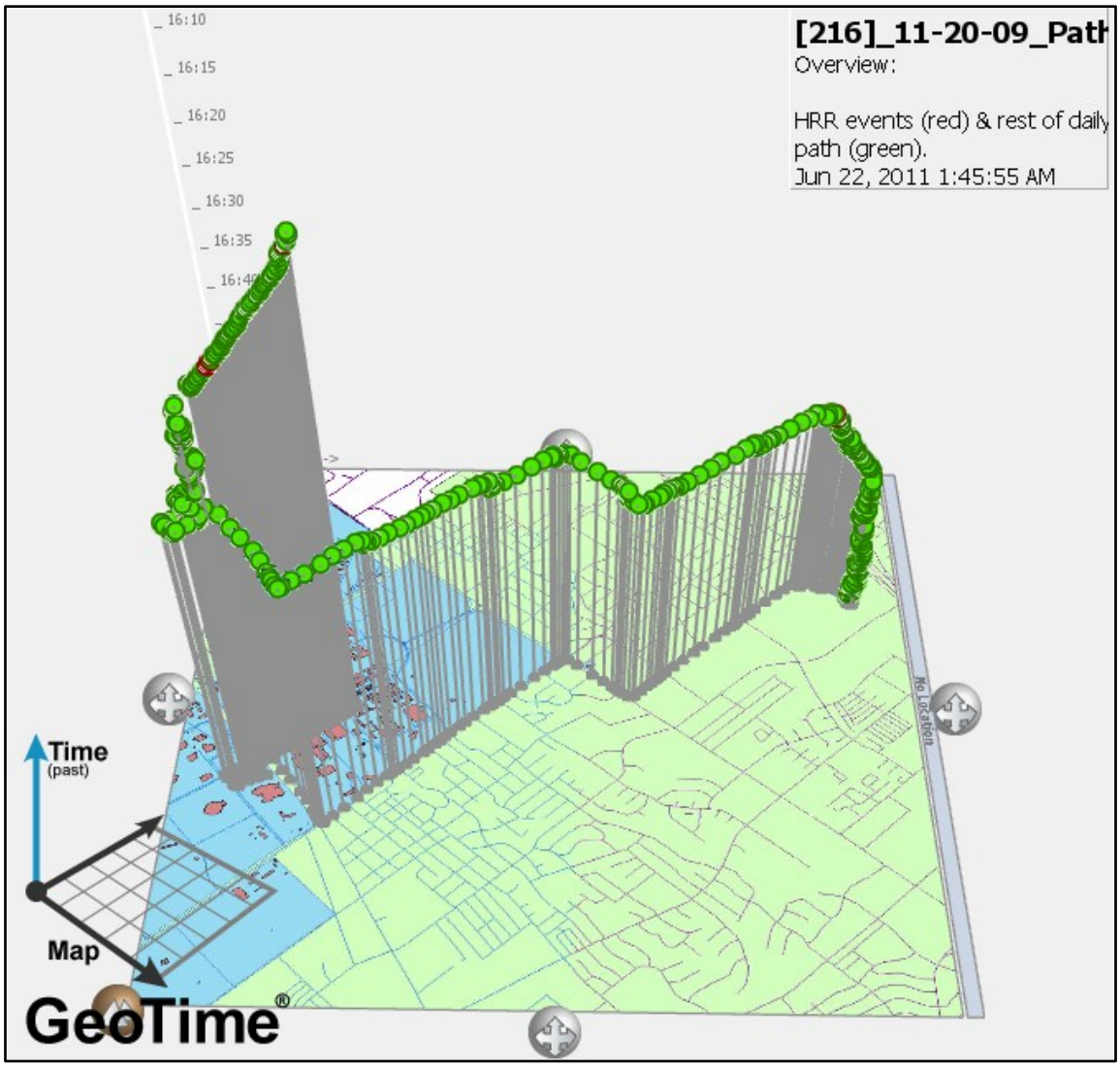



**Figure 75.** Participant 216: map of 11/20/09 daily path.
Note: HRR events are marked in red.

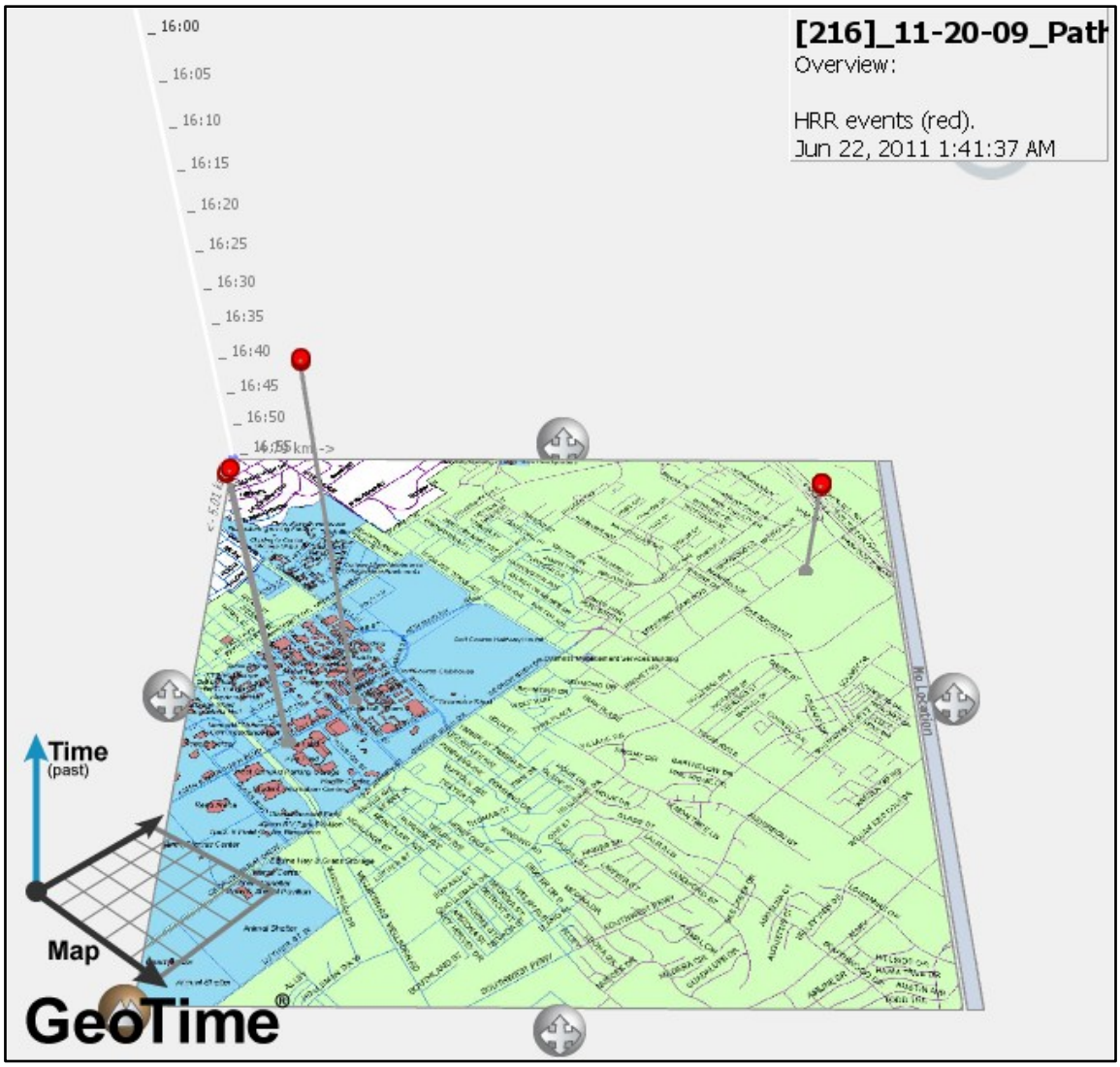



**Figure 76**. Participant 216: map of 11/20/09 logged HRR events.

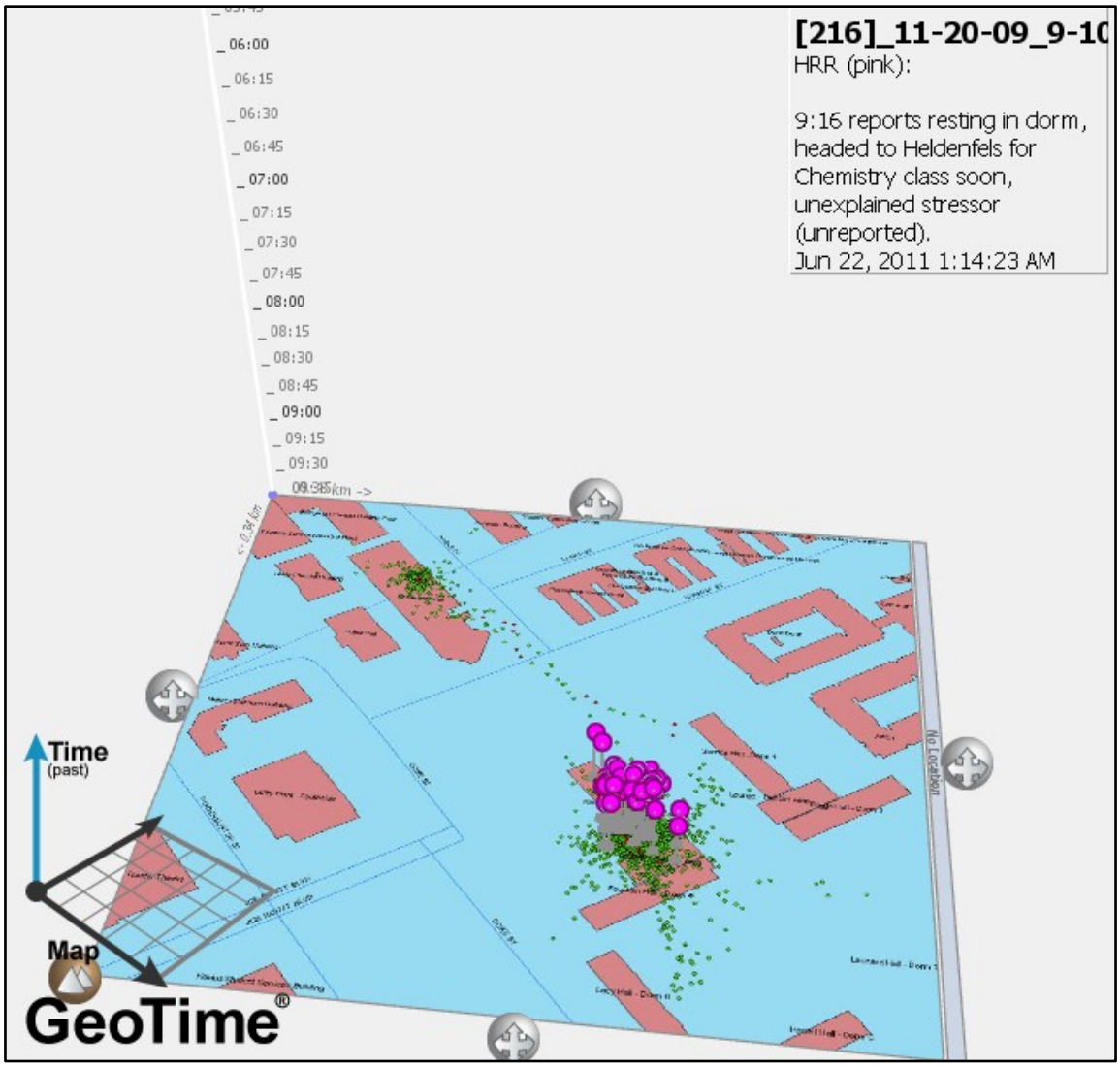



**Figure 77.** Participant 216: map (b) of HRR events.
Note: HRR events are in pink and show participant in her dorm before Chemistry class.

During the third monitoring session (Figures 75 and 76) the participant experienced eight brief HRR episodes between 9:17–9:32 and two of them lasted a minute or slightly longer. *"I'm resting right now in my room so I don't think there'll be any heart rate change. But in a little I'm going to be going into Heldenfels for my chemistry class"*

(Entry 5: 11/20/09 @ 9:16). The HRR events occurred at a time when she reported resting but also said that she would be heading to Chemistry class soon (Figure 77), which was possibly an anticipation of stress. A few hours later the participant reported that she was going to study for a Biology exam but was ambivalent regarding whether this was a stressor or not. Unfortunately, there is no accompanying HR data to shed more light on the experience. *"Okay um I'm going to be studying for my Bio test that's today so my heart rate should go up. Um maybe it won't"* (Entry 6: 11/20/09 @ 11:45).

***Participant 217***

The data for this participant are missing the GPS logs, so the only spatial references are derived from her audio entries. During the first monitoring session, from 10:03–17:53, she experienced six brief HRR events. *"It is 10:45 am I'm in my dorm class and for the past (pause) 40 minutes I have been getting ready for the day. And, now I'm about to start studying Biology"* (Entry 1: 1/20/09 10:44). *"The time is 12:40. I'm at two hours and 36 minutes and I'm back in my room studying"* (Entry 3: 11/20/09 12:39). *"It's 2:30 p.m. Uh… (pause) I'm at four hours and 26 minutes and I'm leaving for a Biology test in Heldenfels"* (Entry 4: 11/20/09 14:29). Each of these entries made by the participant is a potential stressor but the HR data did not log any notable events.

In the second monitoring session (11/21/09), from 13:21–23:21, the participant experienced five HRR events. Three of the episodes lasted a minute or longer, including 13:21–13:40 (19 minutes) and 13:51–14:03 (12 minutes), but neither of these events corresponded to anything discussed in her audio accounts.

*"Session 3 is beginning at 10:14 am… and (pause) I am studying for a Geography test today"* (Entry 11: 11/23/09 10:14). During this monitoring session, from 10:14–20:07 the participant experienced twenty-one short HRR events and four of the episodes lasted a minute or more. *"Time is 12:36 pm… And I just got back from lunch and I'm about to study for geography again"* (Entry 15: 11/23/09 @ 12:35). The participant's stressor was related to academics but studying and attending class did not produce pronounced HRR. *"Time is 2:30 pm… and I'm leaving for Biology class"* (Entry 16: 11/23/09 @ 14:29). Her longest HRR event, 15:53–16:05 (12 minutes) corresponds to heading to Zachary for a Geography exam, which entails physical activity and an authoritative constraint (reported by the participant as biological constraint). *"At 3:53 pm… And I went from Biology to take my Geography test. And, I had a little bit of type B (emphasis) stress, ah...um, (pause) and then at 4:53 pm… And, ah, I got out of the test and, ah walked back to my dorm. Oh and the Test was in Zachary bldg., and Biology was in Heldenfels"* (Entry 17: 11/23/09 @ 17:03). Also, an HRR event lasting from 17:02–17:06 was associated with the participant leaving Zachary after the exam and heading back to her dorm.

***Participant 218***

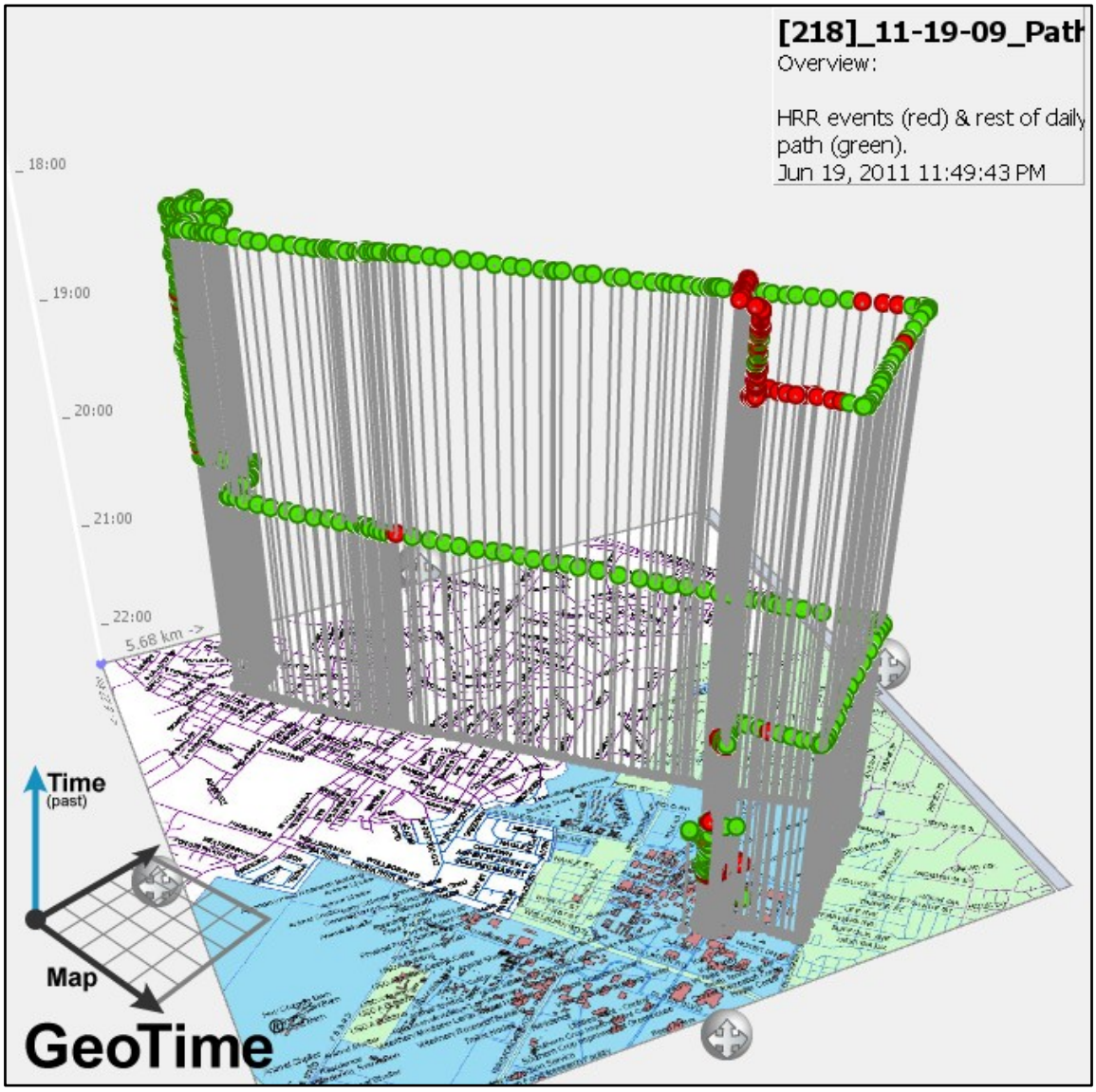



**Figure 78.** Participant 218: map of 11/19/09 daily path.
Note: HRR events are marked in red.

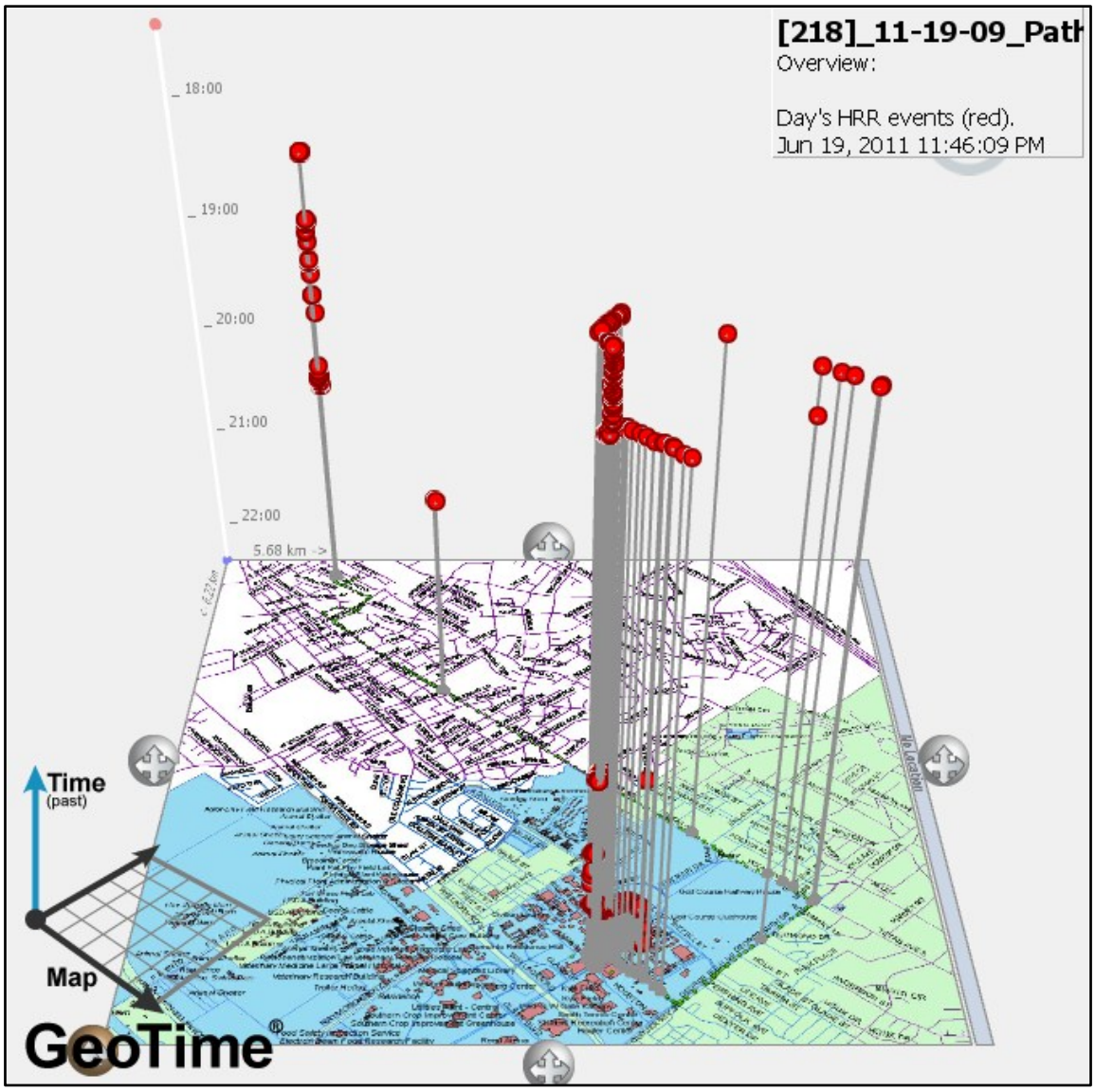



**Figure 79.** Participant 218: map of 11/19/09 logged HRR events.

The participant started her first monitoring session (Figures 78 and 79) with a sense of excitement about the research and urgency to catch a ride. *"Um okay I just came back from your office and I got the supplies for the research project and I don't know. I got all excited [speaking very fast] because we had that conversation and I'm trying to walk*

*really fast so I can get my ride for… [unclear]"* (Entry 1: 11/19/09 @ 17:26). She experienced a 15-minute HRR event from 17:25–17:41, corresponding with the audio entry (Figures 80 and 81).

Later in the evening she reported on an occasion at the Vice President of Education's residence that caused some nervousness. *"I just came back like 15 or 10 minutes ago from the house of the Vice President of Education and his wife and I guess I was pretty nervous during the dinner but I'm over it, a little bit, but yes, I might have had high blood pressure…[unclear] my wrist. [can hear a male voice in the background] Just a quick I didn't mean high blood pressure I meant high rate, sorry. <referring to the last entry>"* (Entry 2, 3: 11/19/09 @ 21:02). Immediately prior to this entry, 20:49–20:56 (7 minutes), the participant experienced an HRR event. In total the participant experienced seventy-nine HRR events in this monitoring session and fifteen episodes lasted 1 minute or longer.

Toward the end of the session she took some time to reflect on the research protocol and then retrospectively discussed the constraints associated with the day's stressors. *"It is 10:12pm right now and I just I was going over the audio diary instructions to see if I was doing it correctly and I realize that I wasn't um saying if it was um I wasn't saying my time nor the duration and I was also neglecting to say the constraint. So I'm going to see if it's possible to do it right now. I know that the first entry when I went out and got the supplies it was a 'C' and then I was walking into class so that I was like physical, like I was walking superfast and um at the dinner party or at the dinner with the Vice President of the Education it was authority and I just got back from my CAMAC*

*[unclear] meeting so that was the probably 'C' coupling since I had to talk with um and track with the other members of the [unclear] and stuff* (Figure 82). *So hopefully this is this is okay and I didn't neglect anything out"* (Entry 7: 11/19/09 @ 22:15).

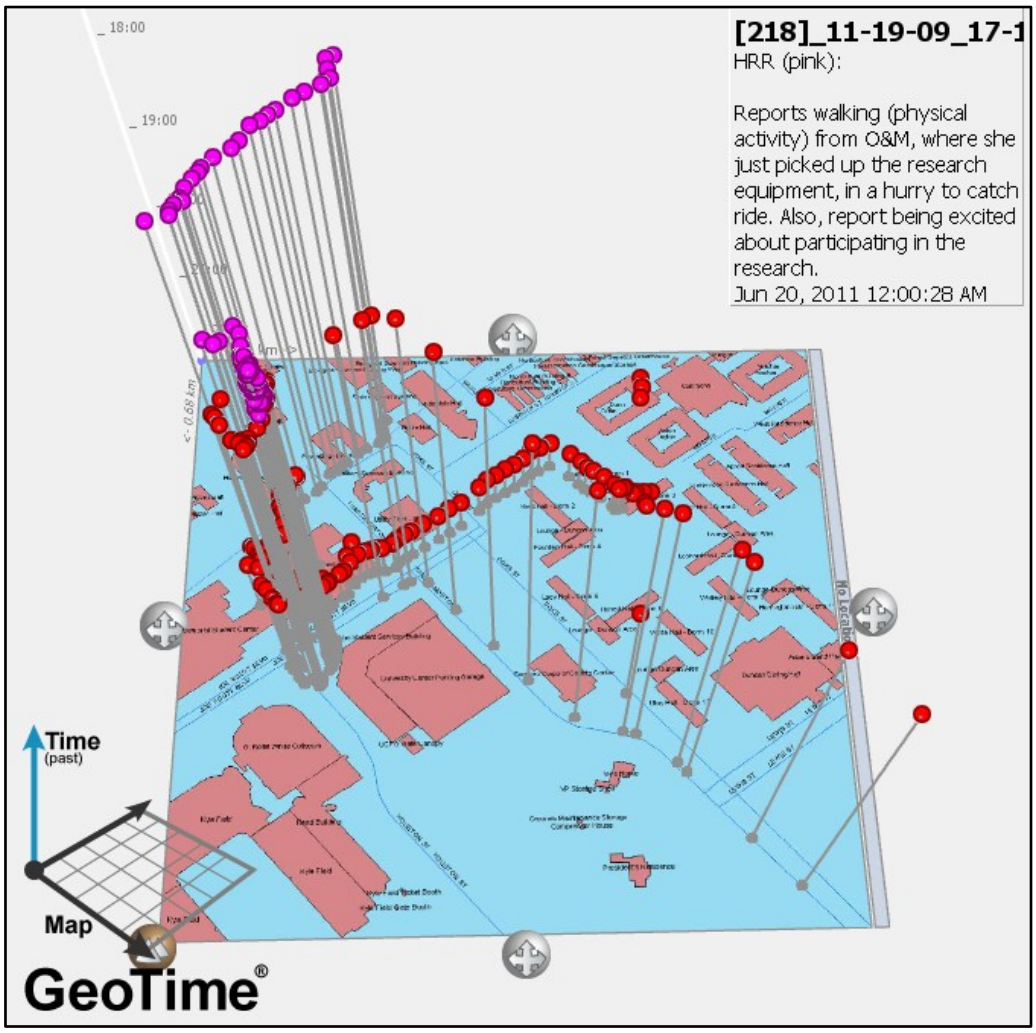



**Figure 80.** Participant 218: map of HRR events (17:00-18:00).
Note: HRR events are in pink and show the participant walking from the O&M Building to catch a ride near Koldus.

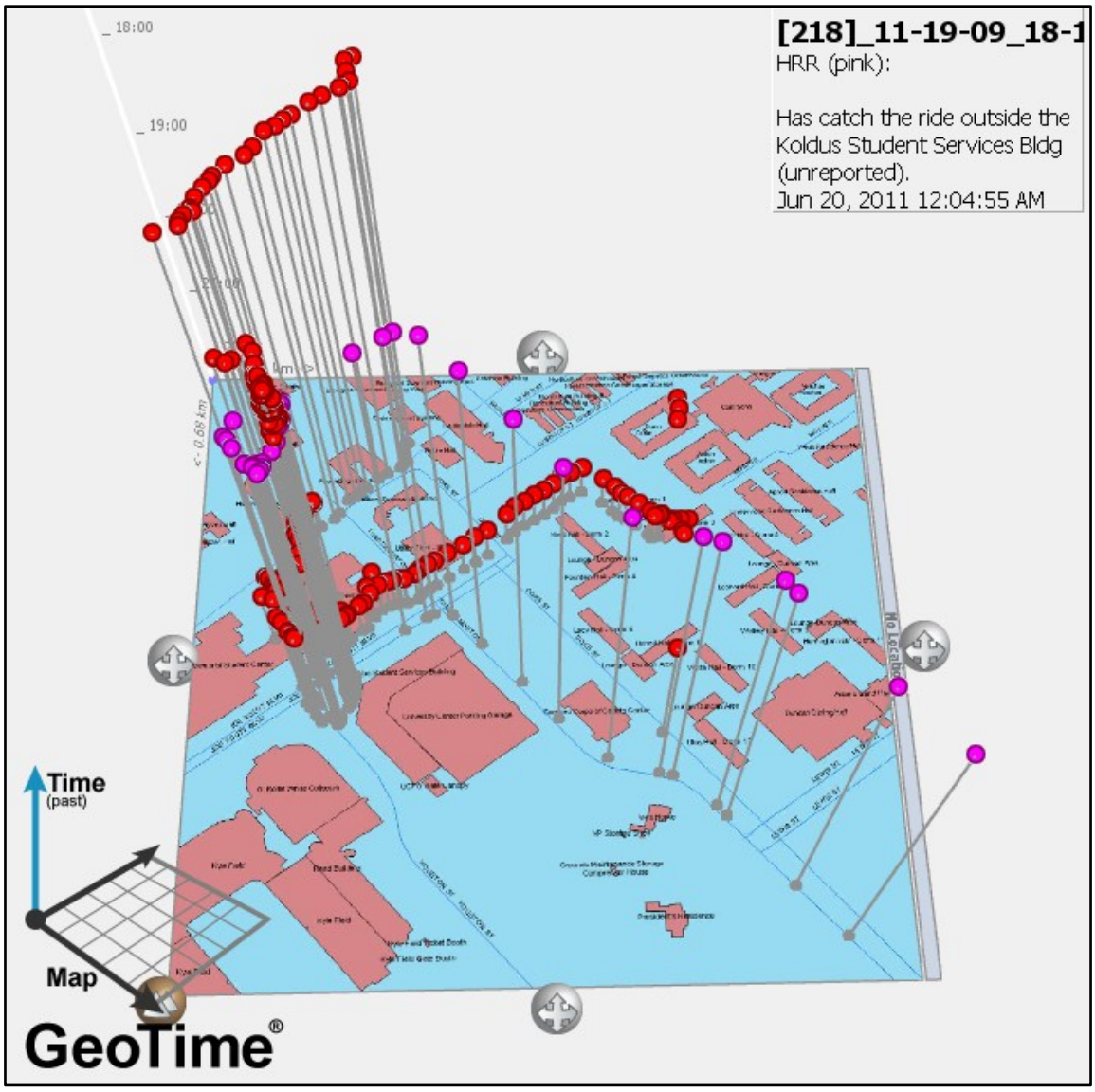



**Figure 81.** Participant 218: map of HRR events (18:00-19:00).
Note: HRR events are in pink and show the participant catching a ride outside Koldus.

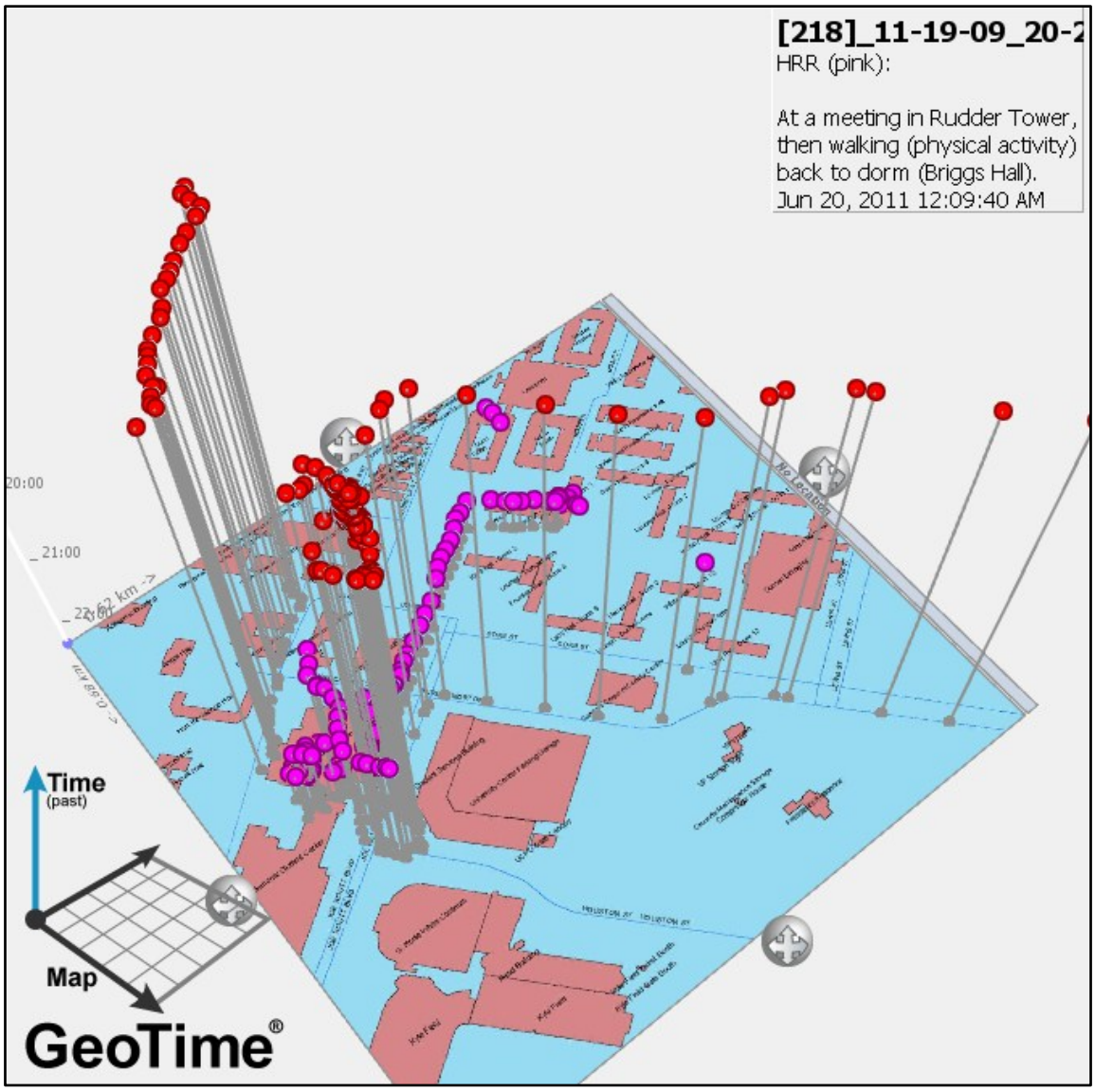



**Figure 82.** Participant 218: map of HRR events (20:00-23:00).
Note: HRR events are in pink and show the participant at a meeting in Rudder Tower and then walking back to Briggs Hall.

The second monitoring session, from 11:23–21:23, began with the participant talking about being in her dorm getting ready for class. About an hour later she was in Blocker Building and seems to have just had a disagreement with her boyfriend. *"It is 12:15 pm*

*and I just finished talking to my boyfriend we talked for about like 16 minutes or so"* (Entry 13: 11/20/09 @ 12:16). *"I am in Blocker building"* (Entry 14: 11/20/09 @ 12:32). *"I'm not sure if there's any change in my heart rate right now but I'm mad right now. It's 12:41 pm by the way…and I'm mad at my boyfriend"* (Entry 15, 16: 11/20/09 @ 12:41). Between 12:19–12:33 (14 minutes) the participant experienced an HRR event corresponding to the time right after her disagreement with her boyfriend when she said that she was mad. Overall, during this monitoring session the participant experienced 151 HRR episodes, most lasting between a few seconds and several minutes. Thirty-three of the events lasted 1 minute or more and eight extended 10 minutes or longer.

The third monitoring session lasted from 11:19–22:03 and consisted of 199 HRR events. There is a gap in the GPS/HR monitor data between 12:06 and 12:49, so there is no evidence to relate to this audio entry. *"It's 12:42 PM and I think I'm getting stressed with 'B' biological my behavior because I haven't studied for my test and I haven't read what I was supposed to for my class"* (Entry 26: 11/23/09 @ 12:51). *"I've been at the library from 2:45 to 3:25 studying and my head hurts so I guess it's 'B' biological stress that I'm imposing upon myself"* (Entry 28: 11/23/09 @ 15:26). From 14:39–14:49 (10 minutes) she experiences an HRR event that corresponded with the beginning of the study period in the library. After leaving the library the student headed to class to take an exam and was still experiencing physical symptoms attributed to the stress of not having adequately prepared. "*It's 3:46 pm and I'm waiting in class and my head hurts because I haven't studied for the test. And I haven't eaten and I'm on my period and I'm mad"* (Entry 29, 30: 11/23/09 @ 15:47). According to the participant's diary entries, several

stressors were contributing to her stress level. In total, during this session, 45 out of the 199 HRR episodes lasted 1 minute or longer and 8 of them ranged from 9–22 minutes.

Later in the evening the participant has an HRR event that corresponds with walking to a celebration, from 18:07–18:24 (16 minutes). She categorizes the stressor as biological but an alternate and arguably better category is physical activity/illness. *"It is 6:21 pm and I am here at Fusion Fiesta and now I had 'B' and physical exertion because I was walking really fast and arranging and I might have a fever"* (Entry 34: 11/23/09 @ 18:22). *"It is 8:48 pm and I'm barely leaving the Fiesta Fusion. And I had a blast! So it's probably 'C' coupling"* (Entry 35: 11/23/09 @ 20:49). During her time at the celebration, from 18:21–20:48, she experienced several HRR events of a few seconds to several minutes, which are attributable to physical activity and excitement. After the celebration the participant reported being back at her dorm studying for a Geology exam the next day. *"It is 9:17 PM and I've started. I'm in my dorm room Briggs and I've started to study for my geology test for tomorrow morning. 'B' biological. <referring to the last entry>"* (Entry 36, 37: 11/23/09 @ 21:18). She labeled the stressor of studying as a biological constraint, presumably attributed to perceived academic shortcomings.

***Participant 219***

The participant did not log spatial data for the first or third monitoring session. During the first session, from 18:31–23:43, he experienced a total of eighty-one HRR events. He experienced several events, including a longer episode from 20:14–20:18, that corresponded with the participant's reported study time. *"It is eight o'clock. I am still in my dorm and I will spend the next 30 minutes studying for my geography test"* (Entry 2: 12/01/09 @ 20:04). From the time the participant reported starting to study until finishing his study period two hours later, forty-six short (several seconds to a few minutes) HRR periods were experienced. The episodes were clustered close to the beginning and the end of the reported study session. *"10 o'clock still in my dorm. Just finished studying for geography and completed some computer science homework. It was pretty stressful but now that I'm done I'm just going to relax for the rest of the night so yeah"* (Entry 3: 12/01/09 @ 22:08). Throughout the five-hour session there were ten HRR events lasting 1 minute or longer.

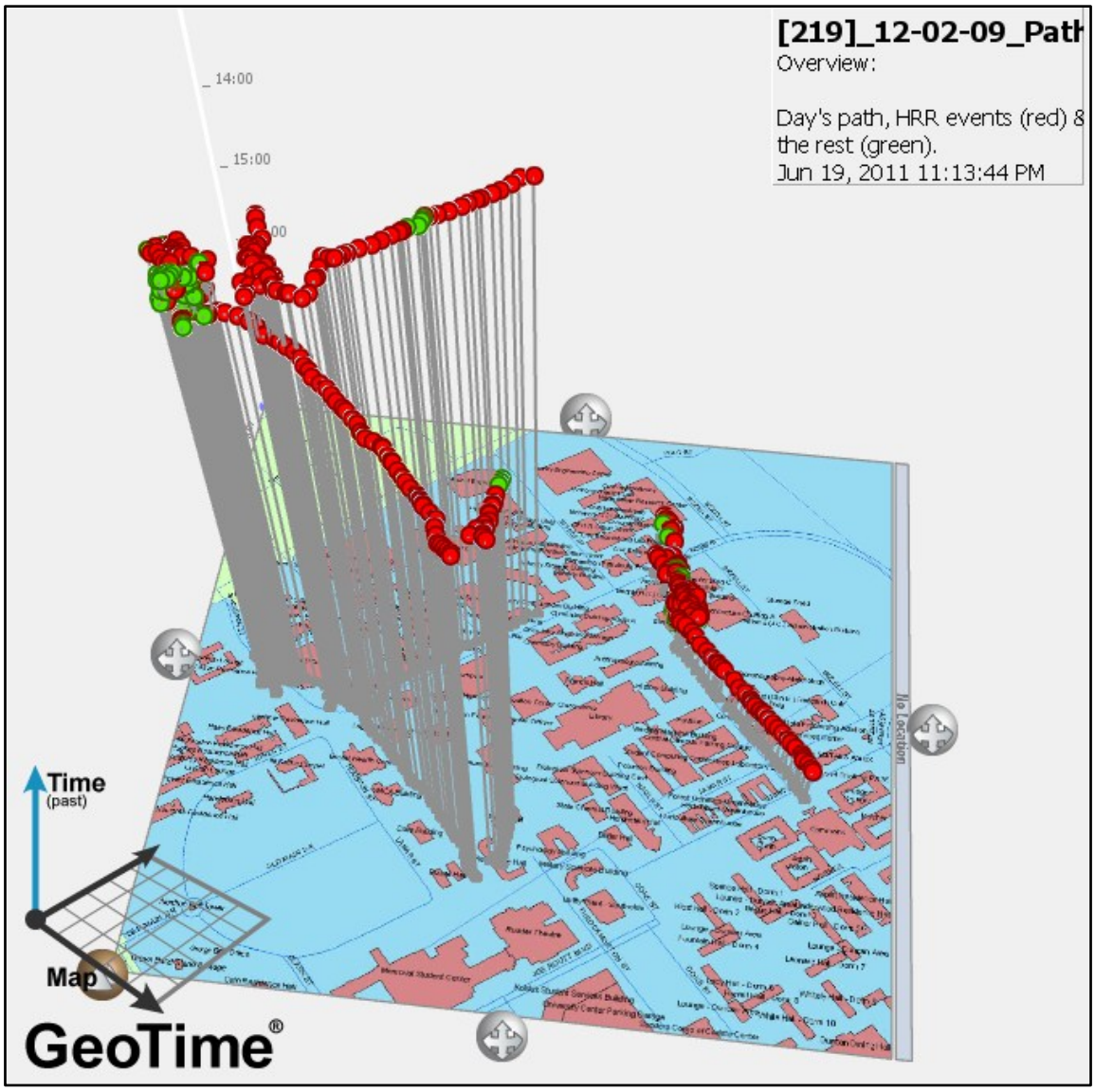



**Figure 83.** Participant 219: map 12/02/09 daily path.
Note: HRR events are marked in red.

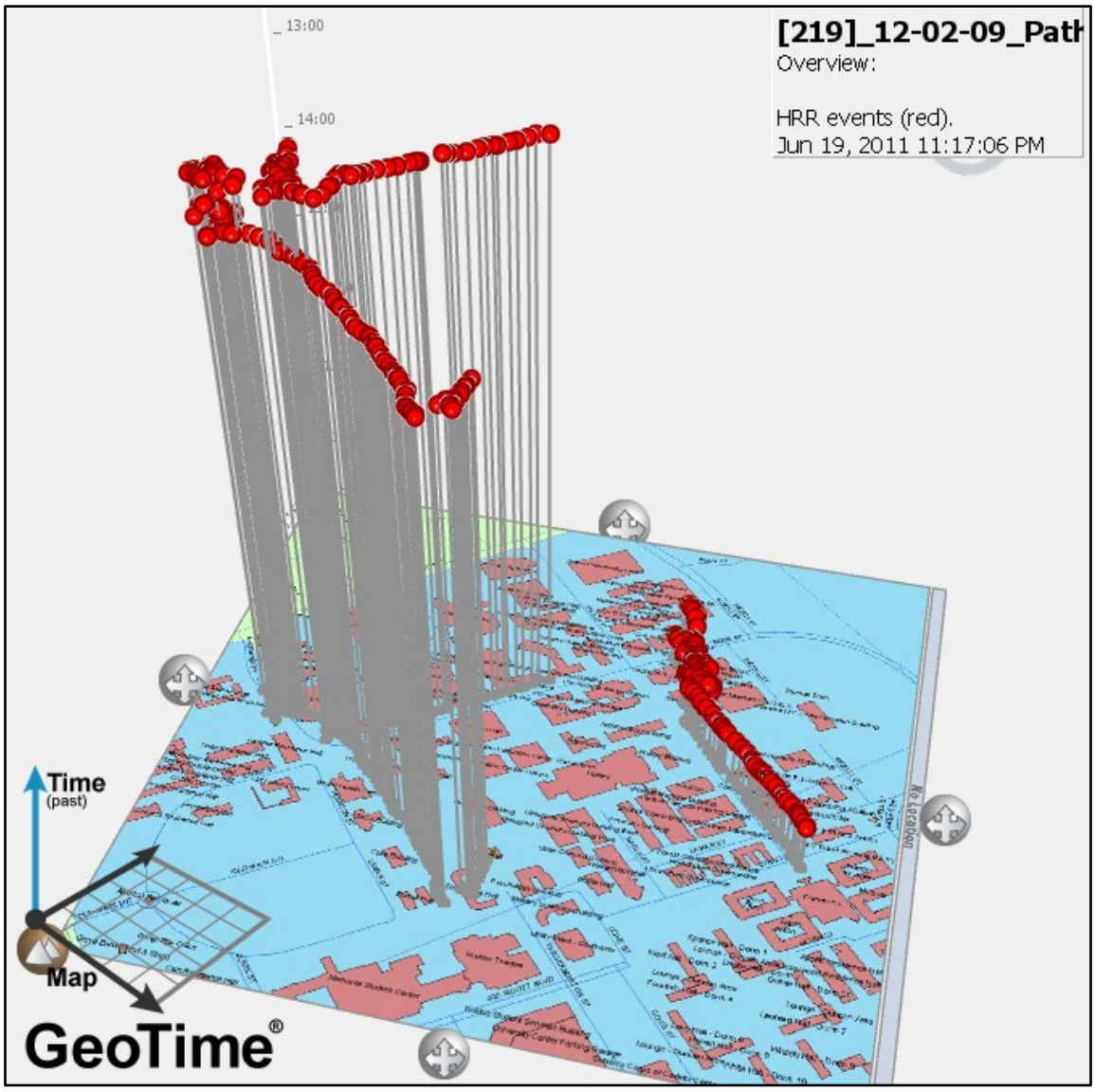



**Figure 84.** Participant 219: map of 12/02/09 logged HRR events.

The second monitoring session lasted from 10:30–01:30 (12/03/09) and the participant experienced a stressor at the beginning but in his rush could not get the equipment to log HR data. *"It's 10:25. I just went to my first class. Um I overslept so I'm pretty stressed out. I can't get this thing to read my heart rate either. So um I guess this*

*would be 'B' because I can never wake up whenever I need to on time. I always oversleep my alarm*" (Entry 5: 12/2/09 @ 10:32). By the time of his second reported stressor of the day, the participant had the equipment fully functioning (Figures 83 and 84). *"It's 12:30. I just got out of my computer science class. I just took a quiz. I did not know some of the questions so I think this would definitely be a 'B'"* (Entry 6: 12/2/09 @ 12:27). He experienced multiple short HRR events during the previous hour, including one from 12:26–12:43 (17 minutes) that corresponds with the end of Computer Science class and then walking to Sbisa Dining Hall (Figure 85). A little later the participant reported being in his dorm studying and experiencing one longer HRR event, from 13:08–13:15 (7 minutes), near the beginning of his studies. *"It is 1:50. I'm back in my dorm. I've been here studying for the past 45 minutes and that is what I will continue doing until about three o'clock"* (Entry 7: 12/2/09 @ 13:53).

Just before 16:00 the participant reported that the exam that he had been studying for was just about to start. *"It is four o'clock and I am in the geography building and I'm about to take the test"* (Entry 9: 12/2/09 @ 15:58). There is a gap in the GPS/HR log from 15:19 to 16:47pm, but starting at 14:47 the participant experienced an HRR episode that lasted 6 minutes (16:47–16:53). Following this event there are forty-seven small exposures of a few seconds up to a minute, leading up to the participant's realization of being late for a study group session (Figure 86). *"6:05 I'm headed to review. I just realized I'm late so that's probably causing some stress right now"* (Entry 11: 12/2/09 @ 18:08). From 16:04 to 16:19 (15 minutes) the student experienced a sustained HRR episode and this was followed by fifteen short HRR over the next 10

minutes. Overall, in session two, the participant experienced 169 HRR events and 10 of the episodes lasted a minute or longer.

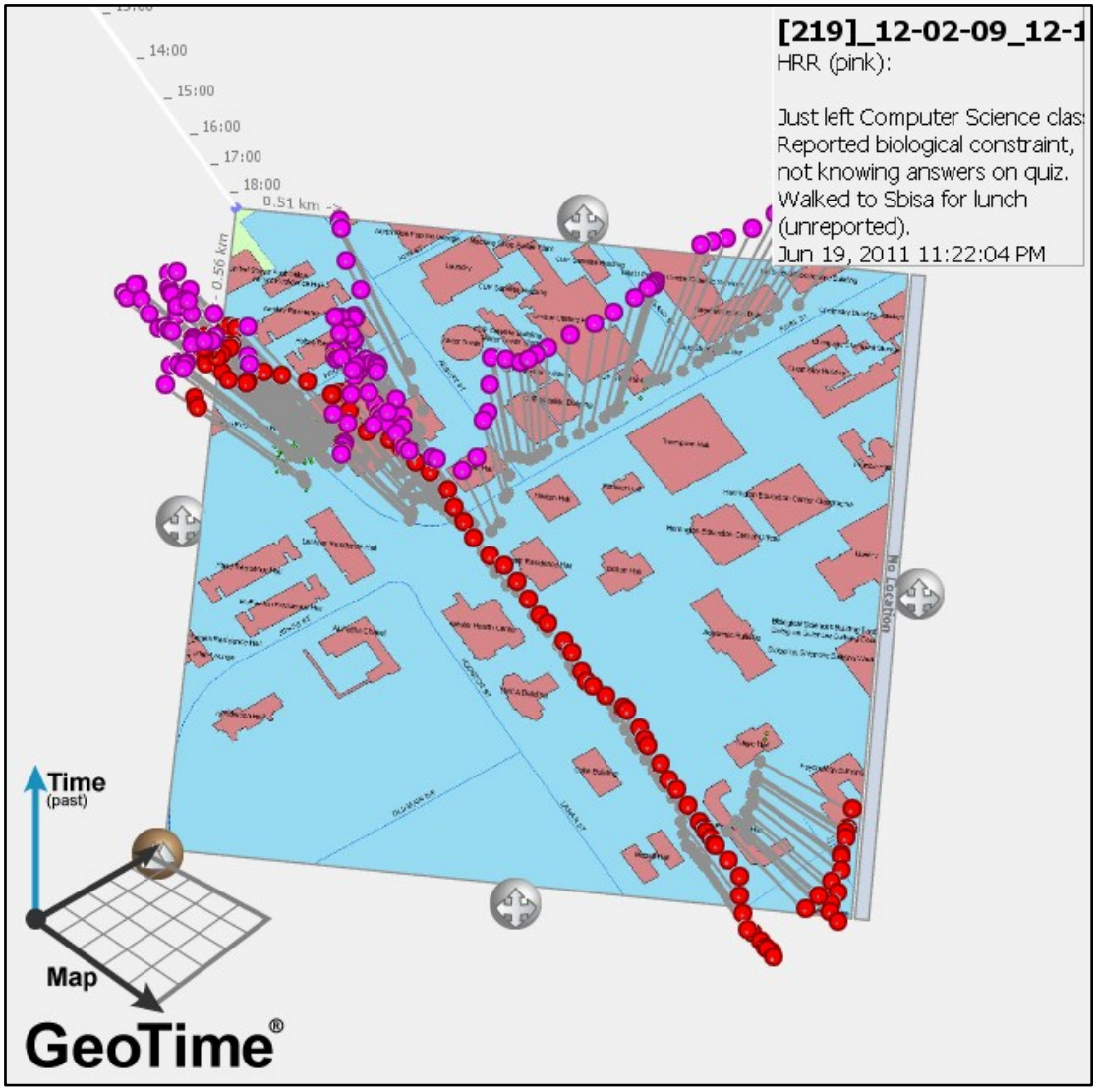



**Figure 85.** Participant 219: map of HRR events (12:00-13:00).
Note: HRR events are in pink and show the participant at the end of a stressful class period and then walking to Sbisa Dining Hall.

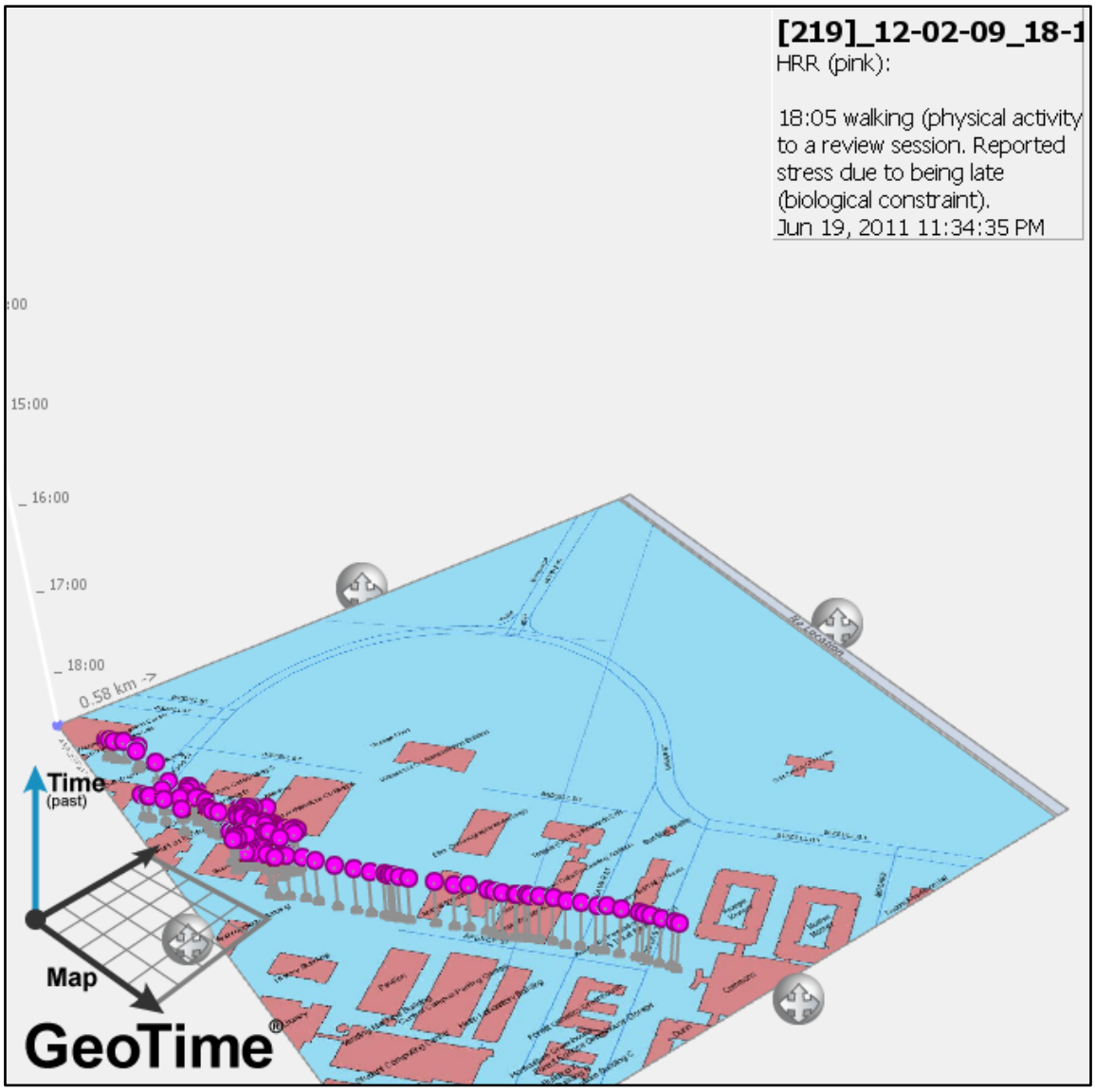



**Figure 86.** Participant 219: map of HRR events (18:00-19:00).
Note: shows the participant walking to a review session that he is late for.

The third monitoring session started with the participant in Chemistry class discussing what he does not like about the class, especially what he does not like about the instructor. His comments correspond to an HRR event lasting from 13:21–13:27 (6 minutes) and 13:34–13:38 (4 minutes). *"It is 1:35 and I'm in my Chemistry class and*

*this would probably be the authority figure stress because my teacher expects us to know crazy random stuff about chemistry that you wouldn't even know unless you're like a doctor and she always talks about like oh if you're going go to medical school you're gonna need to know this. Like we're all going to be doctors. Though I bet you like, not even like five people in there are going to be that. Most of us are like just general studies or whatever majors and it's really stressful having to deal with this, having to know all this crap that I'm not going to have to know after I get out of this class. I hate chemistry"* (Entry 17: 12/3/09 @ 13:24). After the student's telling statements regarding the Chemistry class there are twenty-two HRR events of a few seconds up to several minutes between 13:27 and 14:01.

The participant experienced two HRR events, from 18:55–18:56 (1 minute) and 19:04-19:08 (4 minutes), that lasted a minute or longer that correspond with his registration difficulties.*"7:20 I'm in the basement of the Commons. About 20 minutes ago I tried to register for classes and it caused a lot of stress because the system wasn't working correctly and none of the people who are in charge are available to call so I can't get any help. So I'm going to have to wait until tomorrow before I can clear up everything and finished registering for classes. So that definitely caused a lot of stress on my part probably because of the authority and probably because of myself too"* (Entry 19: 12/3/09 @ 19:19). In total, during the session (12:25–23:28), the participant experienced 242 HRR episodes and 47 of the events last a minute or longer.

***Participant 220***

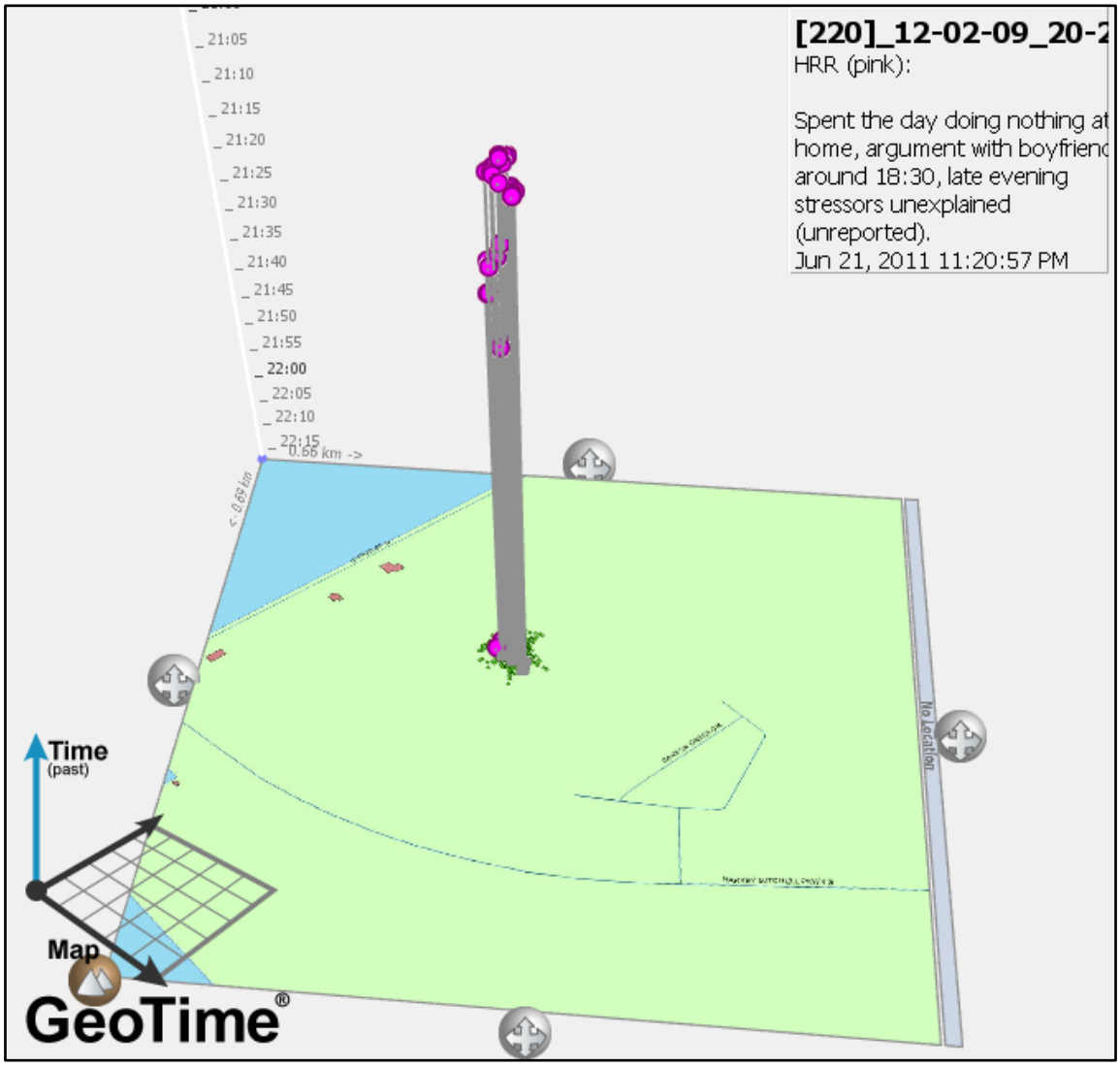



**Figure 87.** Participant 220: map of HRR events (20:00-23:00).
Note: shows an unexplained stressor at home.

During the first monitoring session, from 14:31–22:16, there is a two-and-a-half-hour gap (18:20–20:55) in the GPS/HR log. *"December 2nd at 6:29pm approximately. Um*

*boyfriend just came over and we got into a big argument"* (Entry 3: 12/2/09 @ 18:29). The participant's reported stressor of arguing with her boyfriend takes place during the period when data is missing. The data that were logged shows eleven brief HRR events during the session, all of which were recorded after 20:55 (Figure 87).

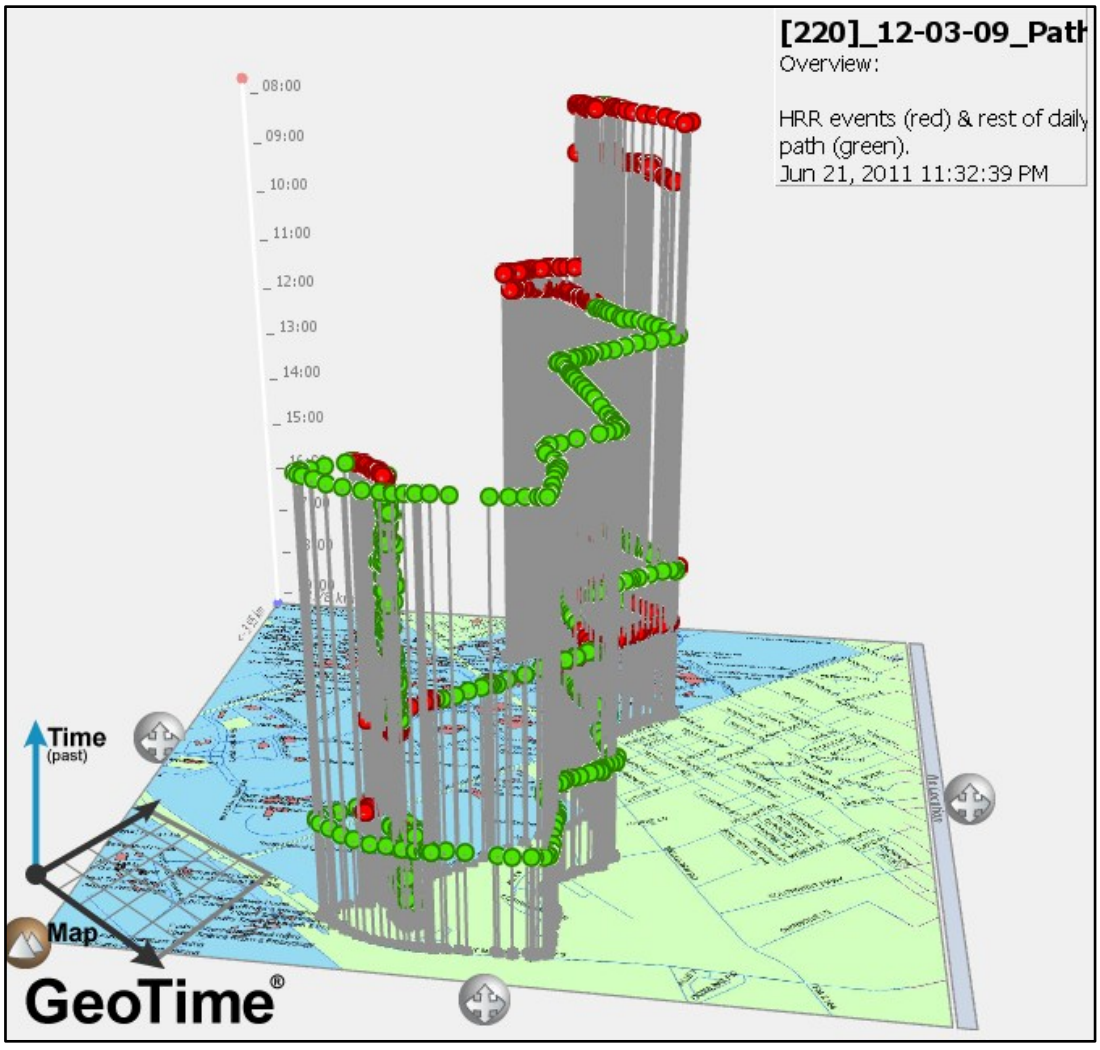



**Figure 88.** Participant 220: map of 12/03/09 daily path.
Note: HRR events are marked in red.

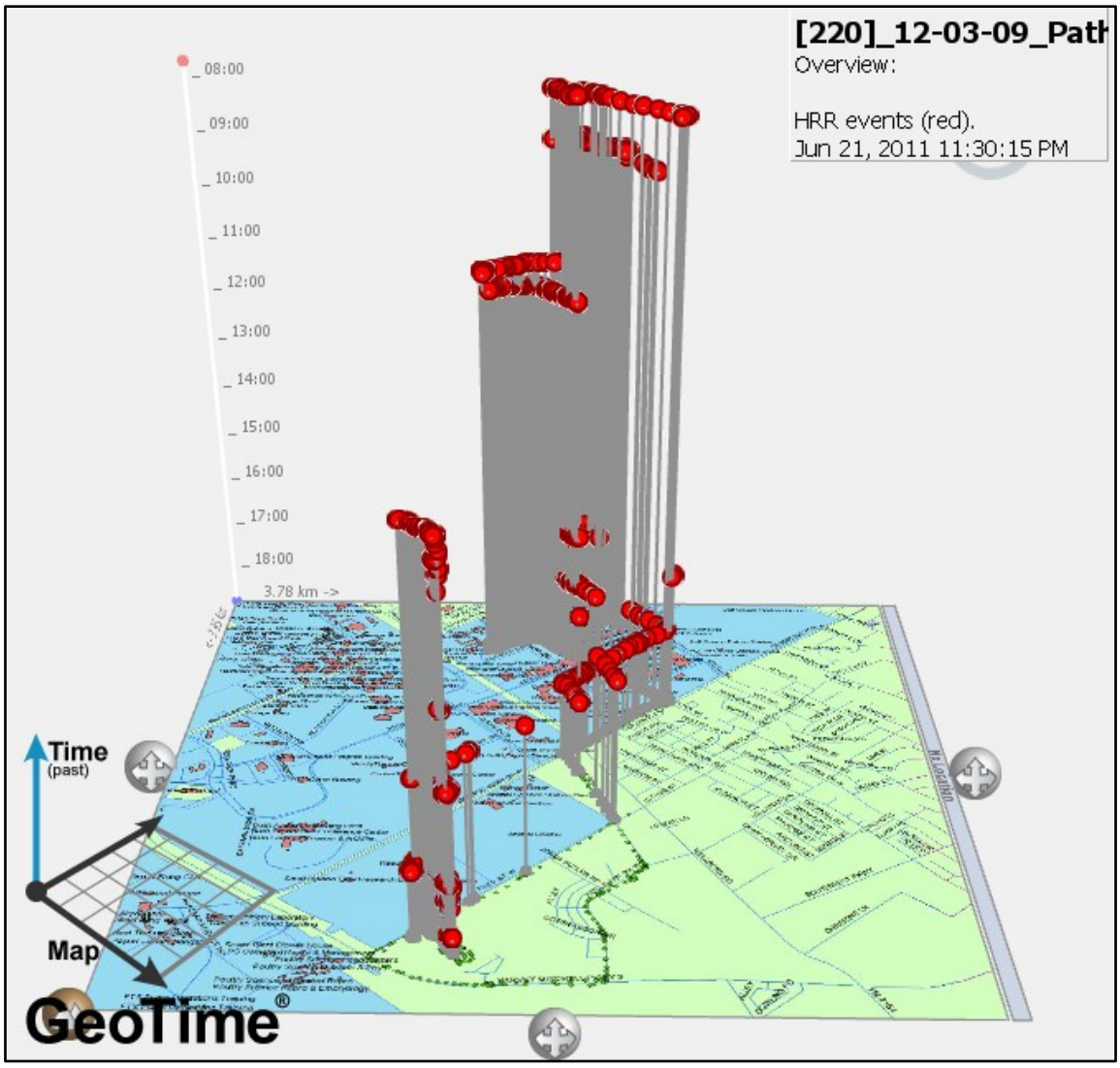



**Figure 89.** Participant 220: map of 12/03/09 logged HRR events.

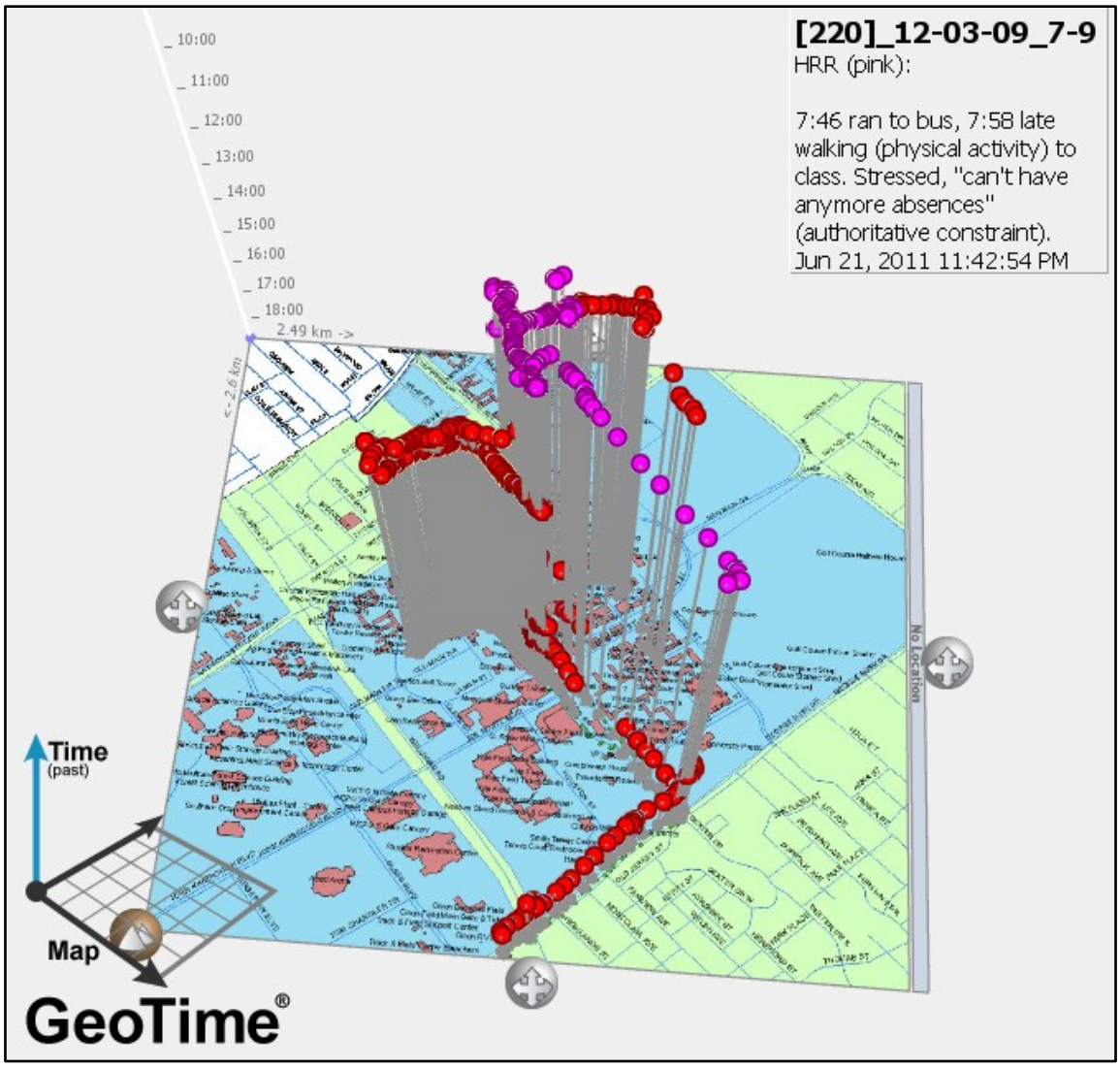



**Figure 90.** Participant 220: map of HRR events (7:00-9:00).
Note: HRR events are in pink and show the participant running late to a class that she can't afford any more absences in.

The second monitoring session (Figures 88 and 89), from 7:52–19:11, started with the participant being late for class (Figure 90). Two HRR events corresponded with her reported feeling of stress and hurrying to class (physical activity), from 7:52–7:54 (2 minutes) and 7:55–8:05 (10 minutes). *"On December 3rd at 7:46am had (have?) to run to the bus. And now I am walking to class, which I am late. So I'm in a hurry and I guess I feel a little stressed because I can't have anymore...(absences?)...[voice trails off]"* (Entry 4: 12/3/09 @ 07:58).

Later in the morning the participant has a meeting with the honors council to face serious academic allegations (Figures 91 and 92). She experience two lengthy HRR events that match up with the meeting time, from 10:51–11:15 (14 minutes) and 11:21–11:32 (11 minutes). *"At approximately 11 o'clock am I had a meeting with the honors council um, which would be 'A' um it stressed me out because I am being accused of something that I did not do and I don't feel that I have to prove myself if I did not do something. So I guess I my constraint associated with my stress would be 'A.' And that was at 11 o'clock to 11:30am and then I walked home and it is now... (11:52am?)... [curt tone, voice trails off]"* (Entry 6: 12/3/09 @ 11:53). She referred to it as an authoritative constraint and had an HRR event that corresponded to making the audio entry from 11:48–11:52 (4 minutes). The honors council meeting is obviously a serious and very stressful event for the student.

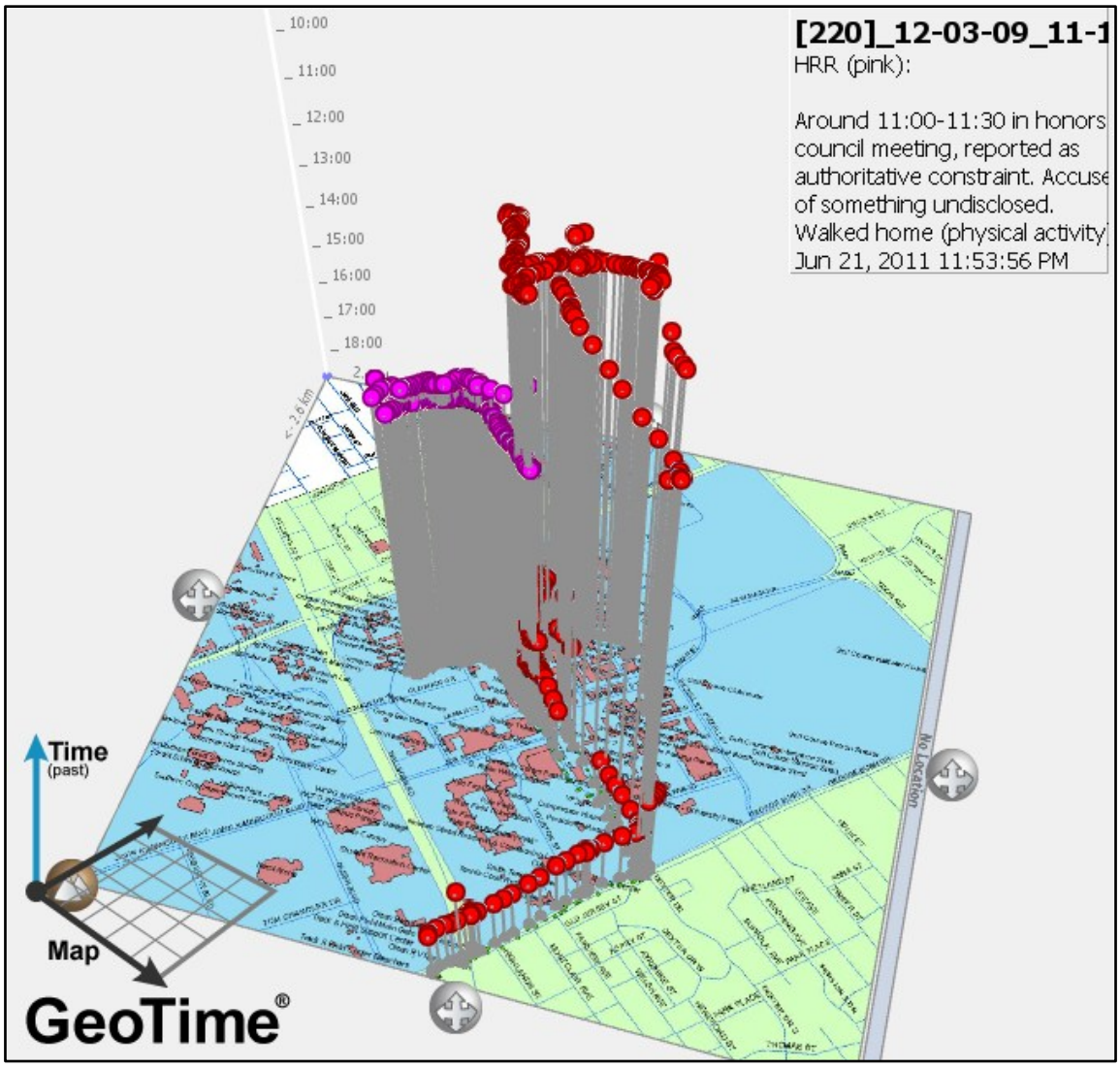



**Figure 91.** Participant 220: map of HRR events (11:00-12:00).
Note: HRR events are in pink and show the participant at an honors council meeting and then walking home afterward.

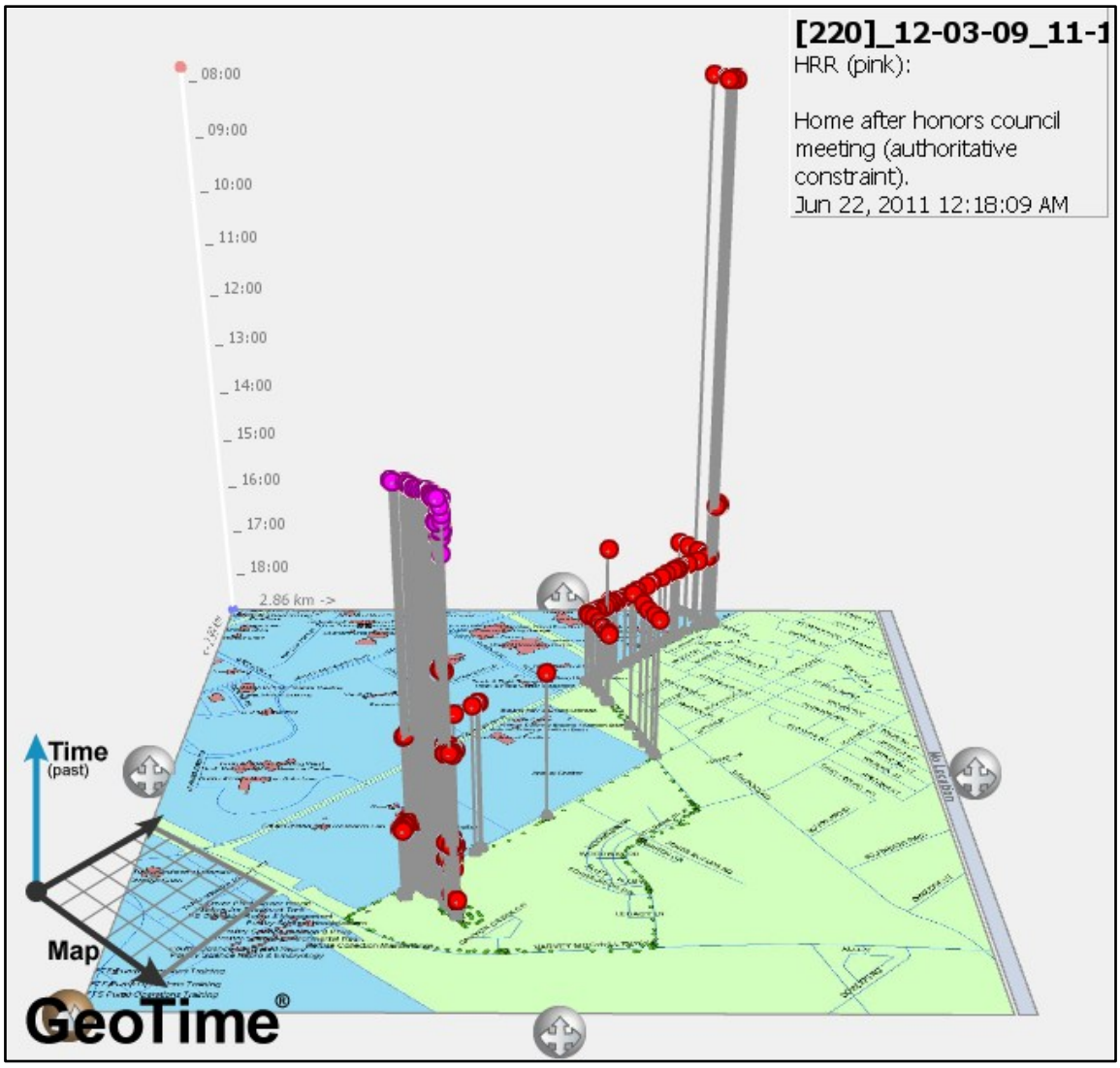



**Figure 92.** Participant 220: map of HRR events (11:00-13:00).
Note: HRR events are in pink and show the participant at home after the honors council meeting.

In the afternoon the participant experienced a stressor associated with oversleeping and missing part of an exam period. *"At approximately 3:55pm I woke up and I had a test at 3:55pm so that caused me stress. And I ran to the bus stop and ran to class. So that would be why my heart rate was up and I was very stressed. My test was located in Harrington building on campus. And the test lasted until about 5:15pm in which I was struggling to finish because it was a hundred question test and I only had 40 minutes to take it since I was 20 minutes late"* (Entry 8: 12/4/09 @ 13:27). From the moment the student woke up realizing that she was late for an exam her heart rate was elevated. The heart rate reactivity pattern shows twenty-four short episodes leading up to and through to the end of the exam period. Her longest HRR events during the exam stressor were from 15:55–16:00 (5 minutes) when she first woke up, from 16:13–16:19 (6 minutes) during the exam, and from 17:08–17:15 (7 minutes) at the end of the exam (Figure 93). Overall the participant experienced seventy-five HRR events during the session and sixteen episodes lasting a minute or longer.

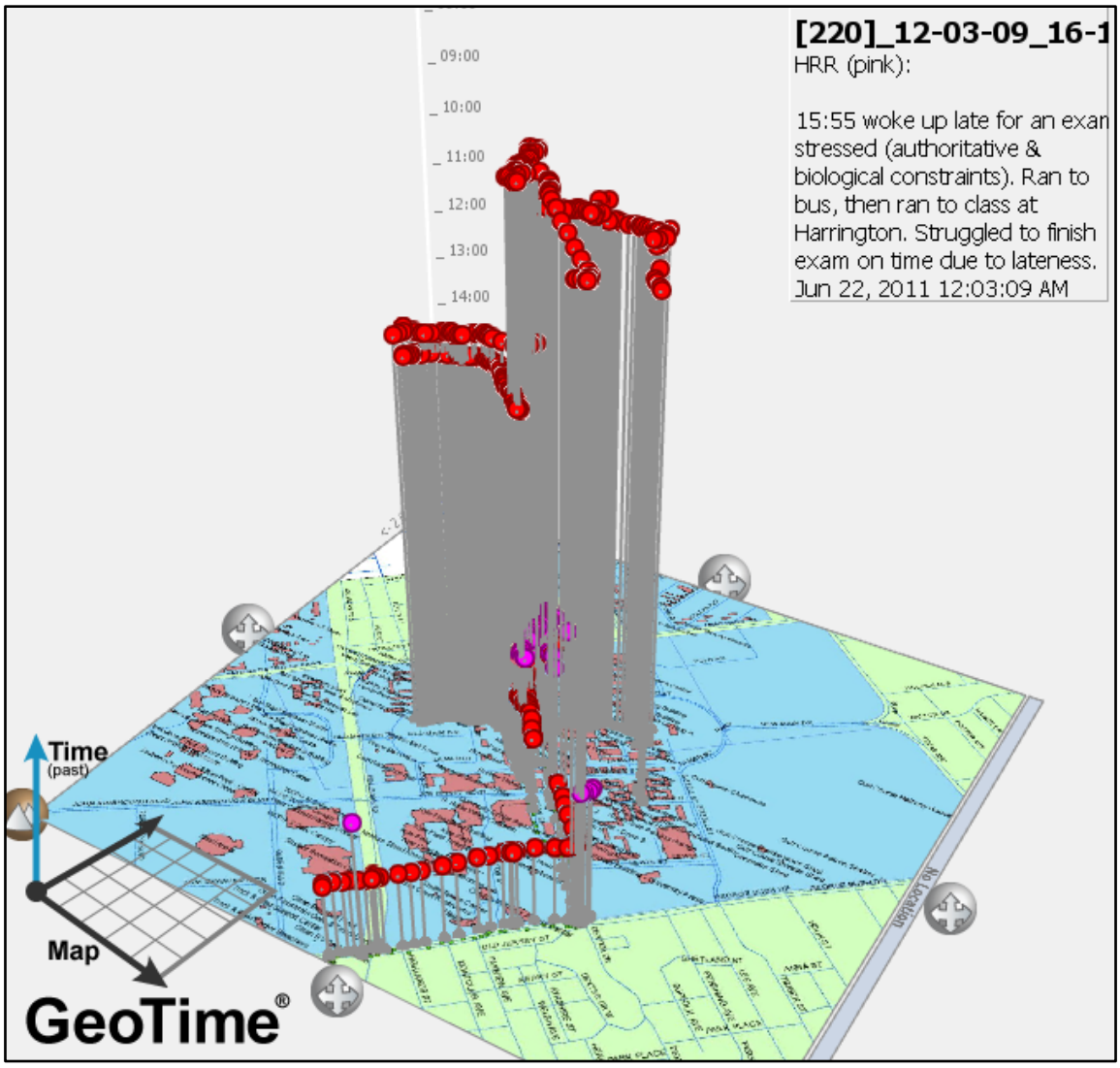



**Figure 93.** Participant 220: map (a) of HRR events (16:00-17:00).
Note: HRR events are in pink and show the participant as she struggles to finish an exam after being late.

For the third monitoring session the participant provided only a few audio entries, or explanations. She reported experiencing stressors related to other drivers while travelling to the Wal-Mart in Bryan, Texas. *"I am being stressed because I am on my way to Wal-Mart in Bryan and people are acting like they can't drive. So I guess this is 'C' because it involves other peoples' non driving. I am currently on Villa Maria and South Texas and it is 1:27 pm on I think today is the 4$^{th}$..."* (Entry 8: 12/4/09 @ 13:27). Later in the day she reports heading to work (Figure 94). *"It is approximately 4:55pm and I am going to work"* (Entry 9: 12/4/09 @ 16:55). The participant did not make notes in her audio entry of stressors at work but from 16:52–20:44 she had multiple HRR episodes and eleven of the events lasted 5 minutes or longer (Figure 95). Overall during the final session the participant experienced 123 HRR events, with 47 of them a minute or more in length.

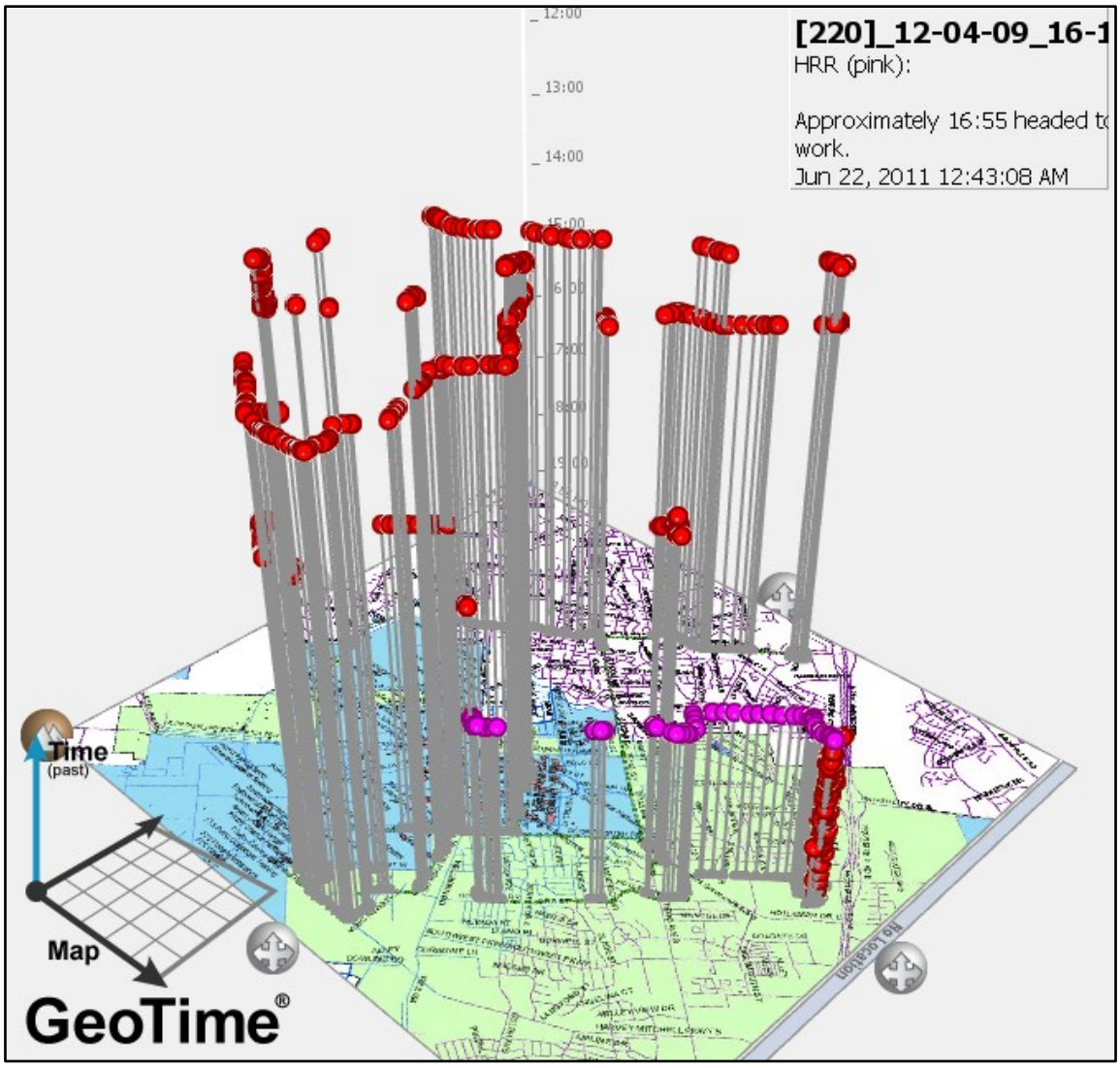



**Figure 94.** Participant 220: map (b) of HRR events (16:00-17:00).
Note: HRR events are in pink and show the participant heading to work, presumably at the mall, based on the location.

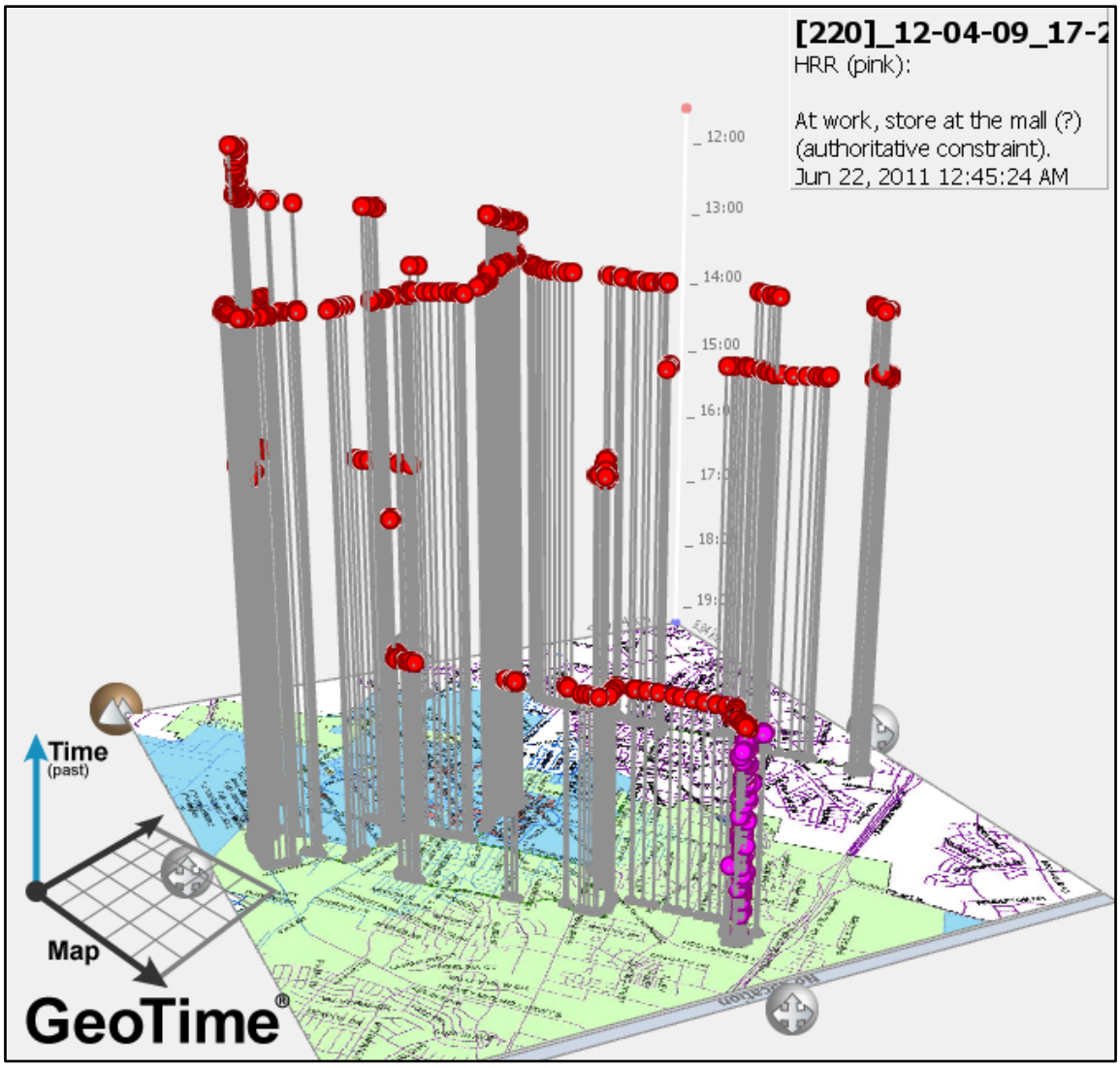



**Figure 95.** Participant 220: map of HRR events (17:00-20:00).
Note: HRR events are in pink and show unreported stressors while she is at work.

***Participant 221***

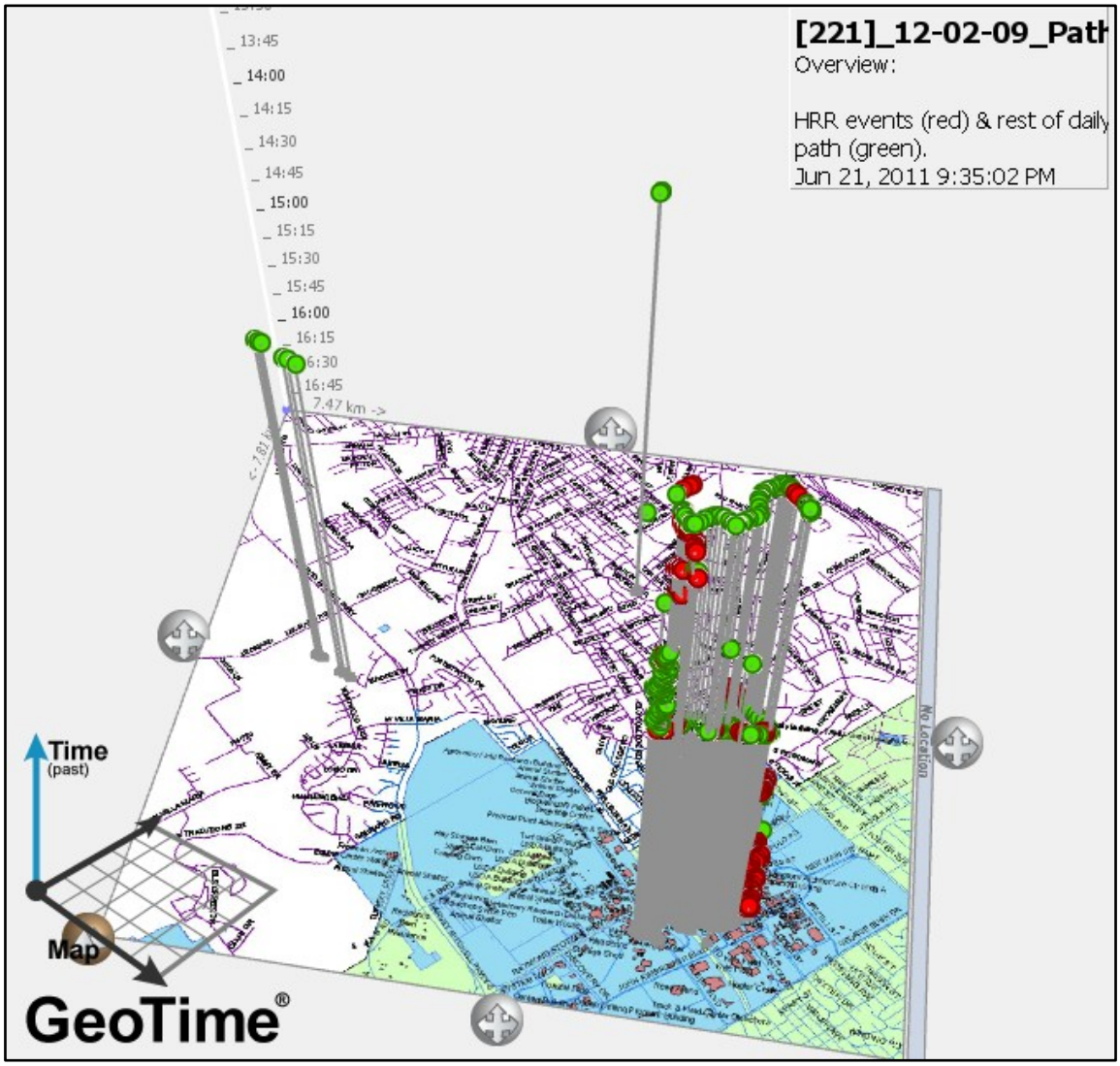



**Figure 96.** Participant 221: map of 12/02/09 daily path.
Note: HRR events are marked in red.

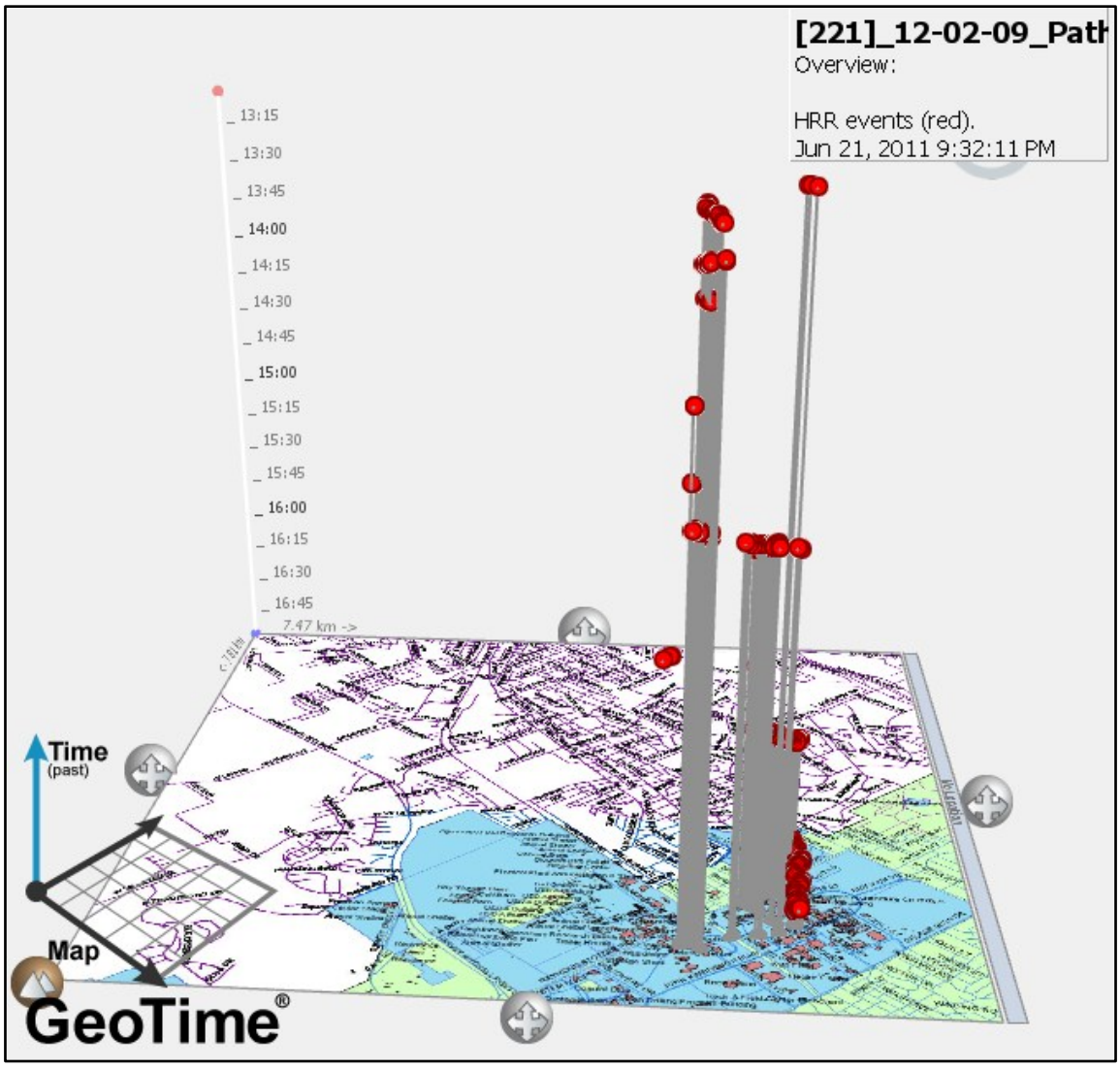



**Figure 97.** Participant 221: map of 12/02/09 logged HRR events.

During the first monitoring session, from 12:49–18:08, the participant experienced forty-seven HRR periods and eleven of the episodes lasted one minute or longer (Figures 96 and 97). His audio entries focused on an academic stressor, a Geography exam (Figures 98 and 99) at 16:00. *"This is * and the time is 1:05 and I just started um the first testing session uh five hours I guess. And um right now I'm on the bus heading to*

*Weiner to get some lunch and then class. That's studying in between and today I'm going to be studying for a geography test I have at four"* (Entry 1: 12/2/09 13:06). The participant had multiple brief HRR events from around 13:00, when he reported heading to lunch and then studying for the exam, through the exam period. Immediately before the exam an HRR event, from 15:54–15:57 (3 minutes), corresponded with the following audio entry and he experienced an episode from 15:59–16:05 (6 minutes) at the beginning of the Geography exam (Figure 98). *"It is um I think 3:55 or so. I'm on my way to geography and [laughs] I'm feeling a little stressed um nervous because uh my test, which is my final in about 10 minutes. So I'm walking on over there now"* (Entry 2: 12/2/09 @ 15:56). An HRR event from 16:40–16:51 (11 minutes) matches up with the participant leaving the exam and walking in the cold. *"The time is 4:40 and I just got out of my test* (Figure 99) *and so I feel a lot more relieved um and I don't feel like I have much of any stress. Although, possibly some physical one when I get outside and it's going to be cold"* (Entry 3: 12/2/09 @ 16:39).

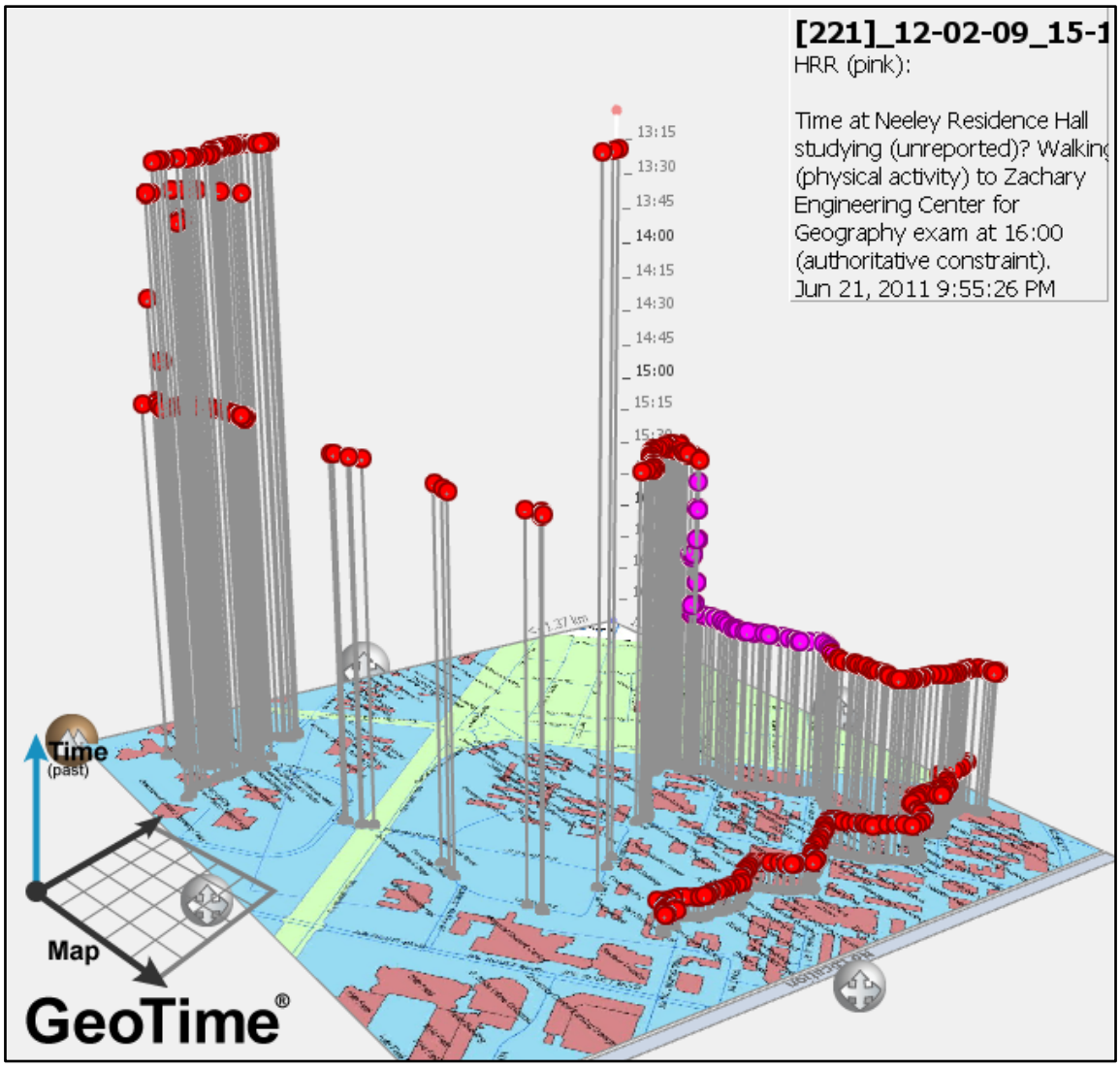



**Figure 98.** Participant 221: map of HRR events (15:00-16:00).
Note: HRR events are in pink and show the participant walking to Zachary Engineering Center for a Geography exam.

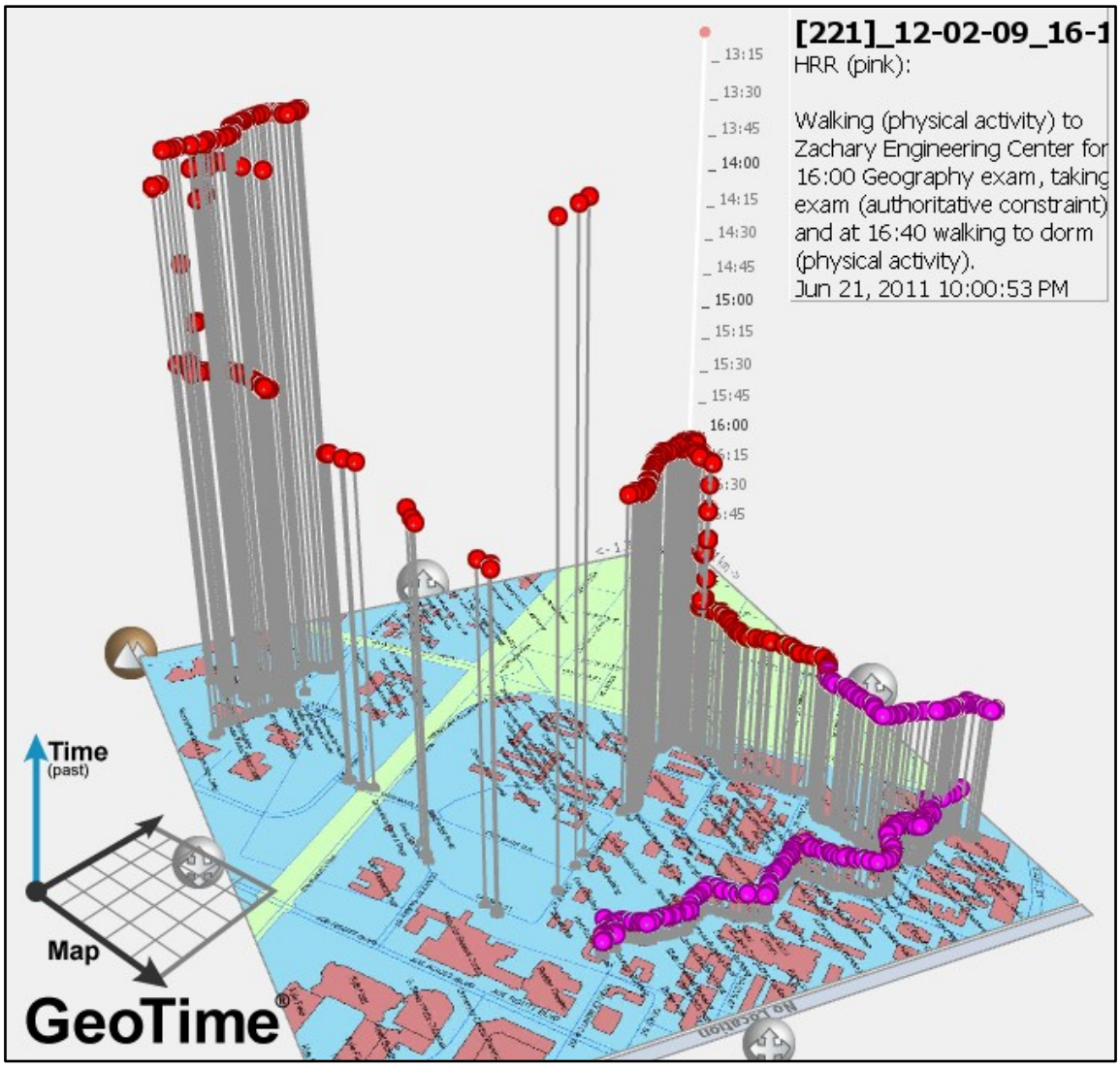



**Figure 99.** Participant 221: map of HRR events (16:00-17:00).
Note: HRR events are in pink and show the participant walking to his dorm after an exam.

The second monitoring session, from 9:46–20:10, found the participant anticipating an economics exam later in the day as a stressor. No spatial data were logged for this session, except for what he shares in audio entries. *"Um I have a test at 2:20 and class at 11:10. It's my final at 2:20 for economics so [laughs] probably be a little stressed in there"* (Entry 5: 12/3/09 9:47). He experienced an HRR event from 13:58–14:03 (5 minutes) that corresponded with the beginning of the Economics exam period. "*It's um I think around 1:55 or so and I'm on my way to economics exam. It's my final [unclear]…hopefully get an A in this class. But I might make a B if I don't get a good enough grade so I'm pretty nervous. I've been cramming in my room for um about the past 50 minutes or so*" (Entry 6: 12/3/09 14:00). Starting approximately 5 minutes before the exam and going until the student reported having finished the exam at 15:10, nineteen brief HRR episodes are logged, with the longest event lasting from 15:03–15:10 (7 minutes) at the end of the exam period.

*"It is um 3:10 and I just got out of my economics exam and um the way it works actually is that we get our test grades, we get to keep the test and we turn the scantron, and then we pick up the answer key on our way out. And so you can find out how you did. Unfortunately, I did not do too well. So I mean it probably means I'll end up getting a B in the class, which I'd hoped for an A but what can you do. So yeah I'm a little bit disappointed. So I don't know if I'll necessarily be stressed. I don't know we'll see. I'll probably be relieved. So I am relieved now that my economics class is just over. [long sigh] But yeah I'm walking back to my dorm now actually and we'll see"* (Entry 7:

12/3/09 15:09). The participant professed being disappointed with his grade in the Economics course but did have HRR events that indicate that as a stressor.

Approximately two hours later he leaves his dorm to meet up with a friend. *"The time is 4:55 on December 3 still and I have just left my dorm… But I'm going now to meet up with, with a friend of mine and so I'm a little excited. [Laughs] And um yeah, I think I might be getting some coffee, I'm not sure, we'll see"* (Entry 8: 12/03/09 @ 16:54). He experienced two HRR events, from 16:55–17:00 (5 minutes) and 17:03–17:09 (6 minutes) that correspond to the reported excitement and physical activity. Overall during this session the participant experienced ninety-nine HRR events and twenty-one of the episodes lasted a minute or longer.

For the third monitoring session, from 9:10–19:25, there was a lot of movement to and from various places on campus (Figure 100). The participant made only a few entries and they were not very detailed regarding stressors of the day (Figure 101). *"It's 12:47 um. I don't remember if I told you it's December 4. And it's snowing [someone in the background is echoing the same words] and I'm really excited about this. So probably my yeah I'm just really excited and happy. So that is all. Oh I might be doing a little [unclear] running, which might be considered exercise. [Laughs] And it's really cold out so my heart rate probably will be high"* (Entry 10: 12/4/09 @ 12:48).

His entry about snow and excitement corresponded to an HRR event from 12:40–12:49 (9 minutes). About an hour later the participant discussed a possible stressor in his Accounting class related to the upcoming final exam. *"It's about 1:37. I'm in ah Weiner and I'm about to go to class. It's accounting, and yeah, it should only be about 50 minutes. We might talk about the final, which might make me a little nervous and that should be it"* (Entry 11: 12/4/09 @ 13:38). He experienced a significant string of HRR events, from 15:27–15:53 (6 minutes), 15:54–16:11 (7 minutes), and 16:12–17:25 (73 minutes), that corresponded to his account of playing sports. *"It is 5:50 or so and I'm eating dinner right now. Um I meant to record this earlier but for like the past hour or two and half, I don't know how long, I've been playing sports outside so, that should, that probably added some, I don't know heart rate elevation…"* (Entry 12: 12/4/09 @ 17:44). In total for this session, the participant experienced 195 HRR events and 43 of the episodes last 1 minute or longer.

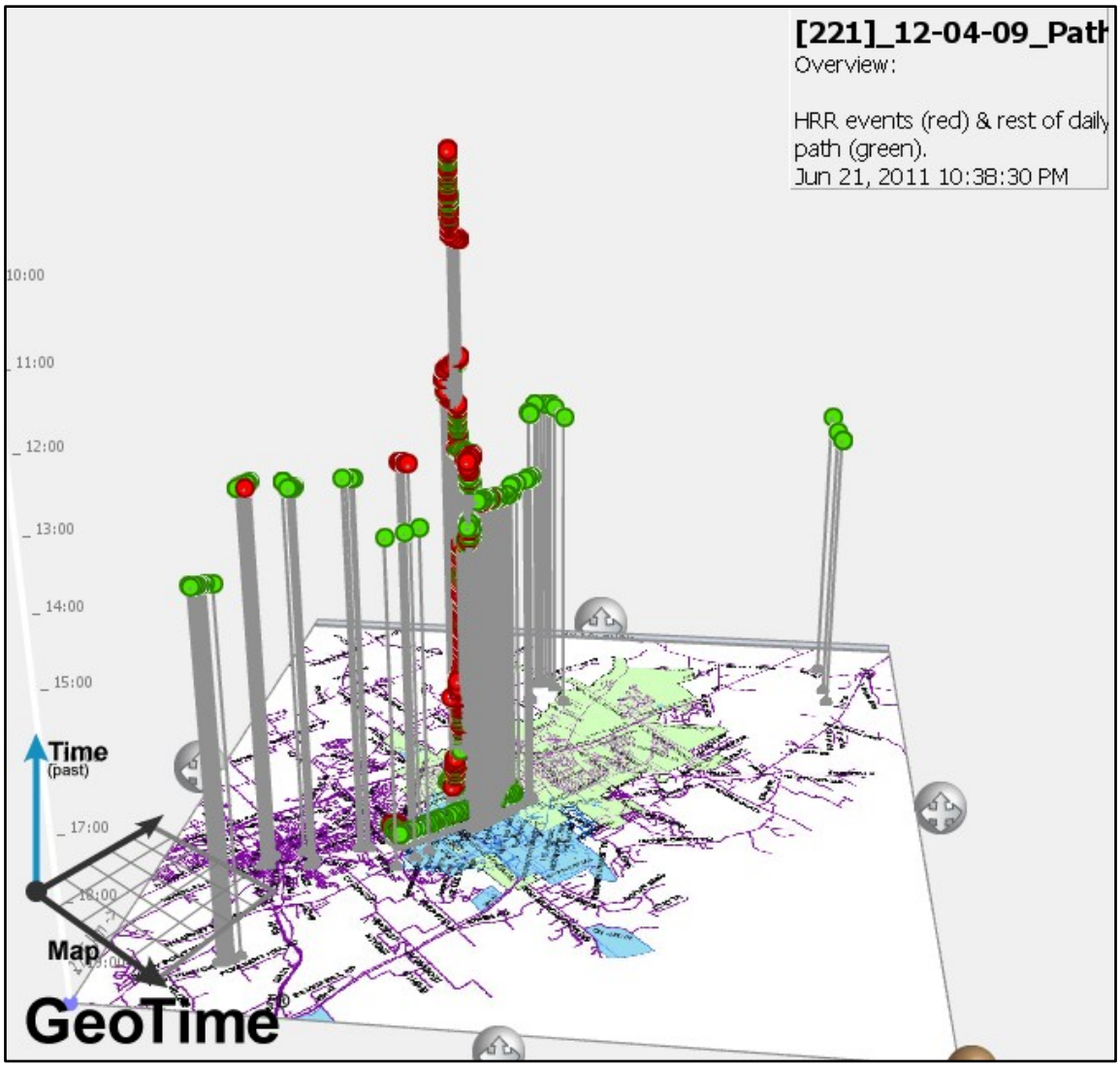



**Figure 100.** Participant 221: map of 12/04/09 daily path.
Note: HRR events are marked in red.

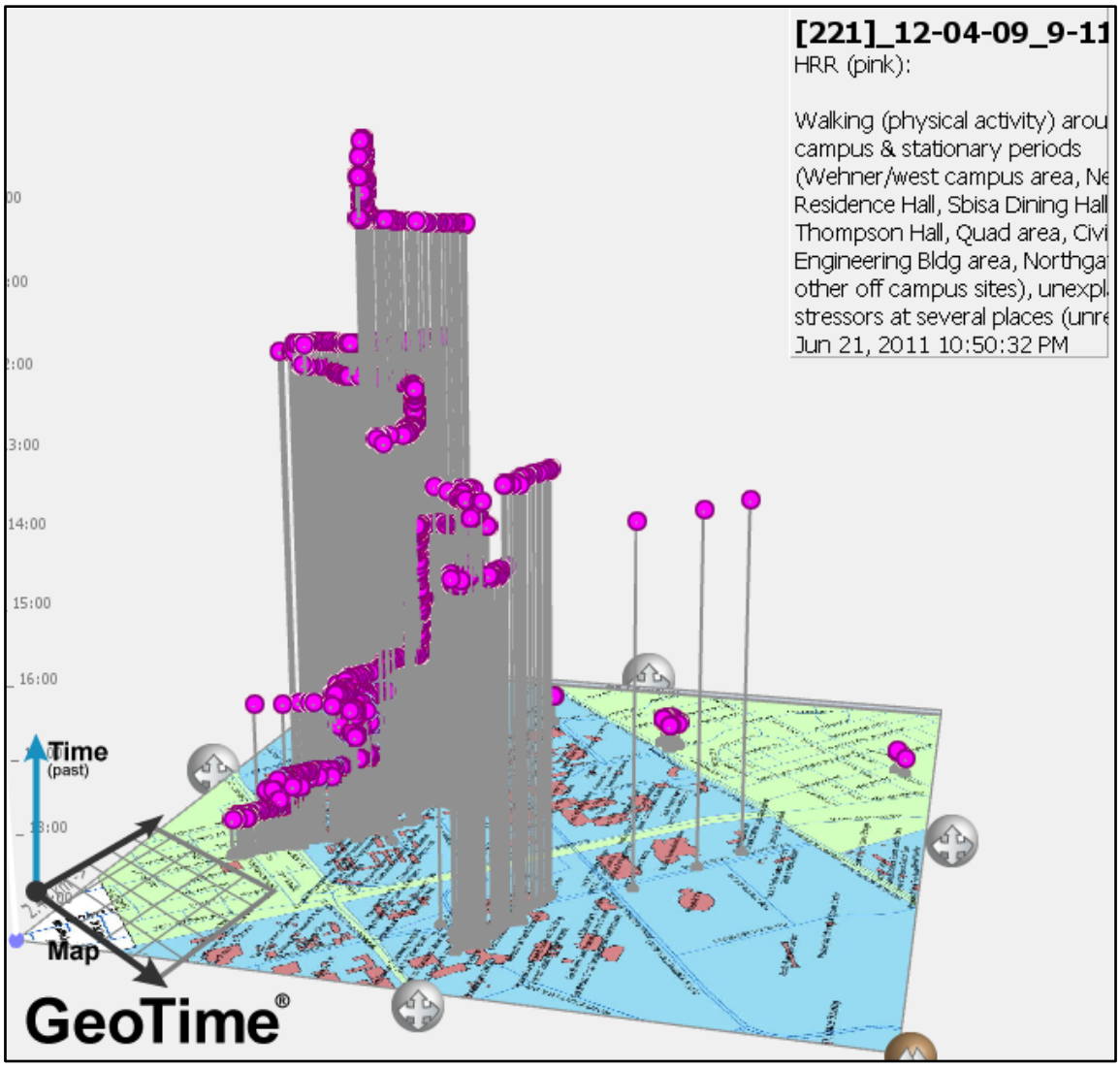



**Figure 101.** Participant 221: map of 12/04/09 logged HRR events.

***Participant 222***

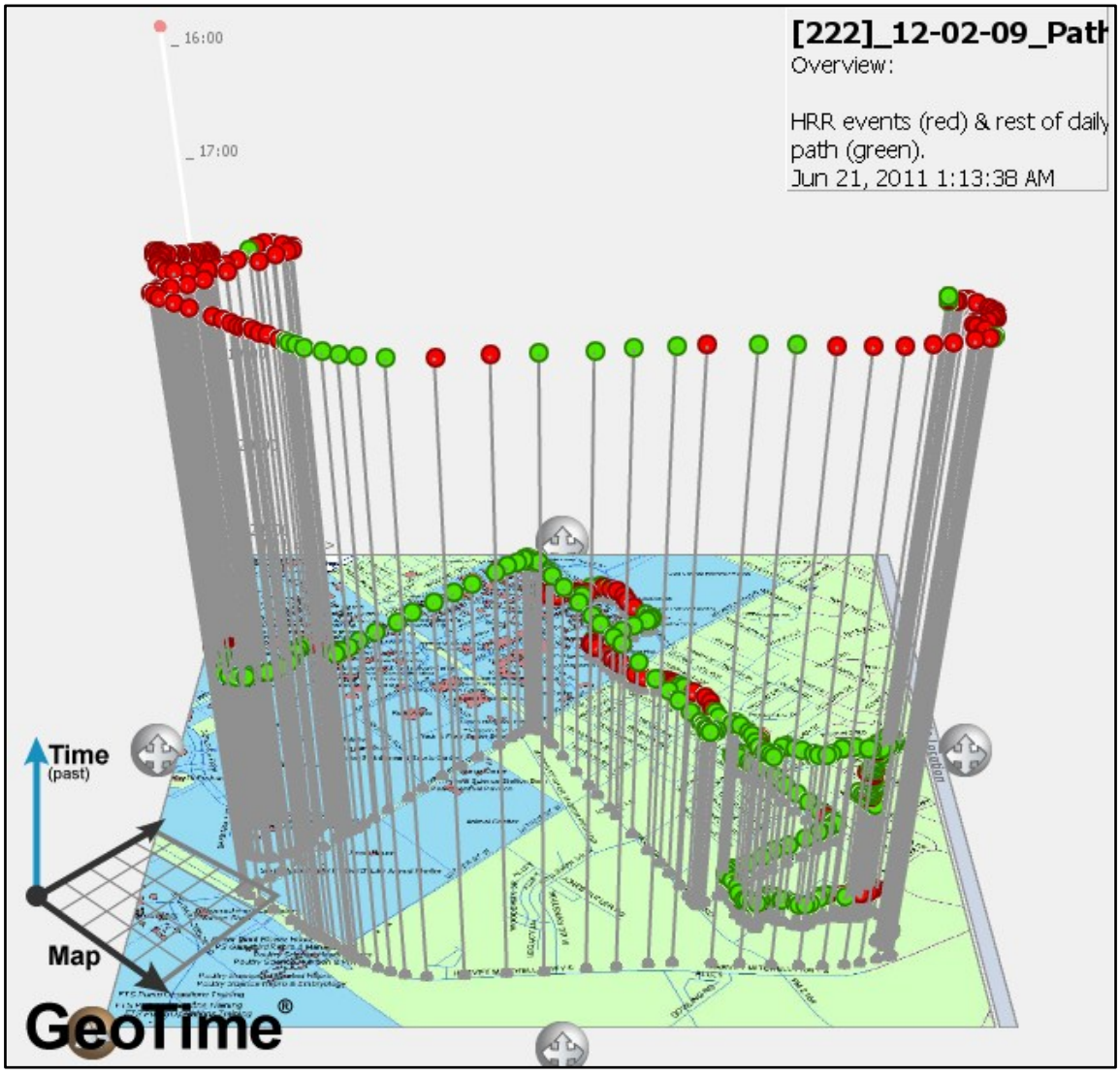



**Figure 102.** Participant 222: map of 12/02/09 daily path.
Note: HRR events are marked in red.

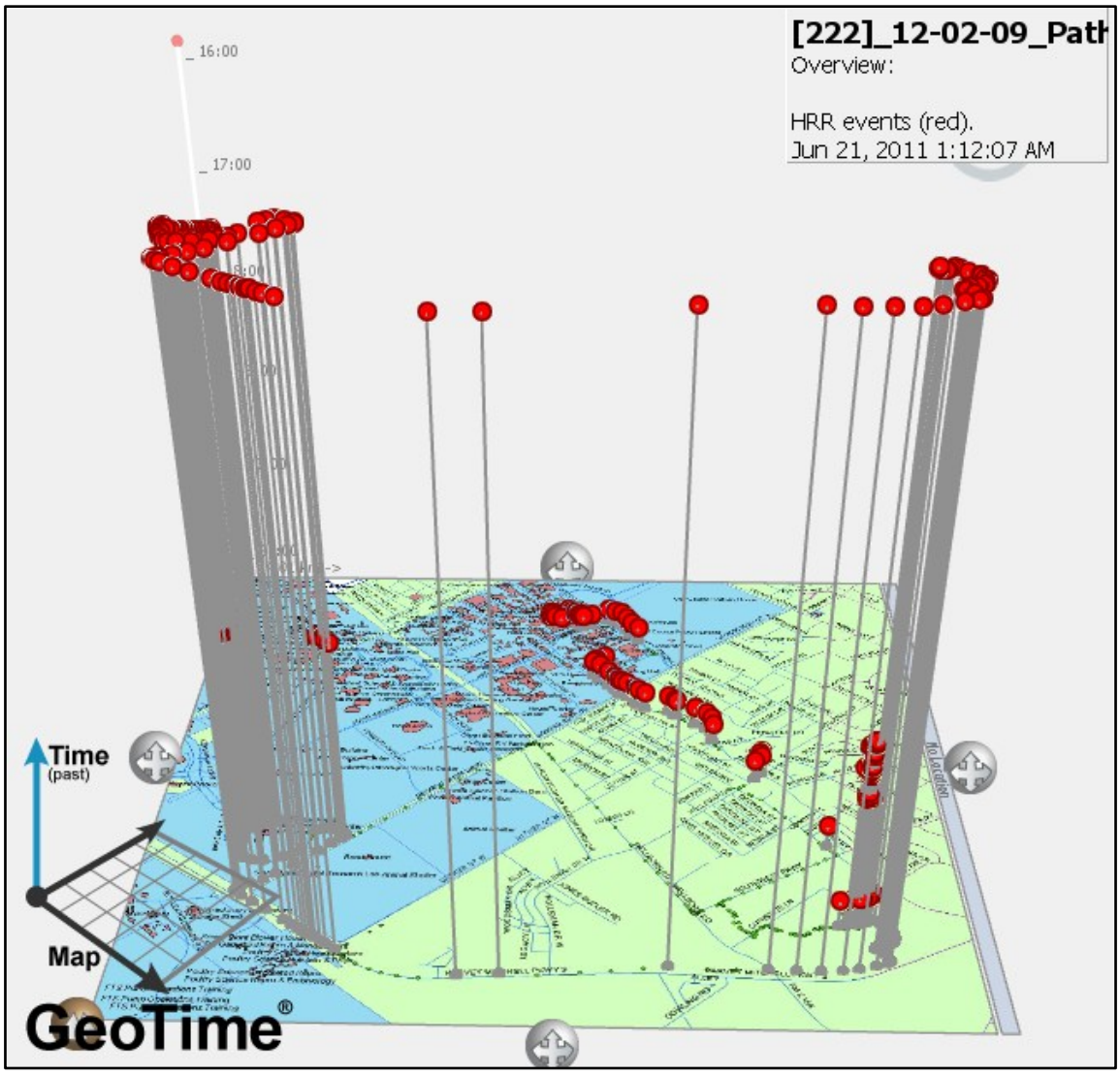



**Figure 103.** Participant 222: map of 12/02/09 logged HRR events.

During the first monitoring session, from 15:54–21:29, the participant experienced ninety-seven HRR events, with fourteen episodes lasting 1 minute or longer (Figures 102 and 103). *"Hello it's 3:54 on my first day of testing. I am about to leave from my apartment to head to the Alan building on West campus to study for a test* (Figure 104) *that I have six. I have been stressing a little bit about the test so I'm sure my heart rate has been elevated all day so we'll see how it goes"* (Entry 1: 12/02/09 @ 15:53). The log recorded an HRR event, from 16:04–16:08 (4 minutes), right before he headed inside to study for a few hours. *"It's now about 4:10 PM and I'm about to go inside to the Alan building to study for about two hours before my test. Um right now I'm probably feeling um…let's see what kind of stress it is um the physical mental the biological ability um that's probably what I'm feeling right now just a little stressed about the test. And hoping I do well so um possibly there maybe a little bit environmental stress a just from being in this building because I associate the building with the class that I don't like. So it gets my heart rate a little mad because I really do not like my professor so that stresses me out so in about two hours I will update you right before the test"* (Entry 2: 12/02/09 @ 16:10). He used the audio entry to discuss the stressor of the exam but also reflected on the fact that he did not even like being in the building because it reminds him of the class, including the professor whom he particularly does not like. *"It's about six o'clock now and I'm about to take my test. Um my stress level is kinda going up a little bit. Getting nervous this is the final and a lot of the class is kind of worrying about it. Um first I accidentally turned my a the GPS off. It was paused for about 30 minutes…*" (Entry 3: 12/02/09 @ 18:02). In the previous audio entry he reported having accidentally

turned off the GPS/HR monitor, which occurred between 17:10–17:46 (36 minutes). *"Um but I've just been studying for the past about two hours and I will take the test in just a few minutes"* (Entry 3: 12/02/09 @ 18:02). In the period between when he went out to study until finishing the final exam shortly after 19:00, there are fifty-five HRR episodes lasting from a few seconds to slightly over 4 minutes in length.

Later in the evening the participant discussed what he had been up to since the exam and what he planned to do for the rest of the evening. *"It's now about 8:45… Um I've been at my apartment for about the last hour or so hour and a half. And I would have, I ate and did some I took an online quiz so is mostly relaxed um and now I'm going to the West Campus library to study for a test* (Figure 105) *I have tomorrow afternoon"* (Entry 4: 12/02/09 @ 20:46). Three HRR events of more than a minute each, 21:07–21:11 (4 minutes), 21:13–21:16 (3 minutes), and 21:17–21:25 (8 minutes), corresponded spatially to the participant heading to the West Campus Library to study for an exam that he had the next afternoon.

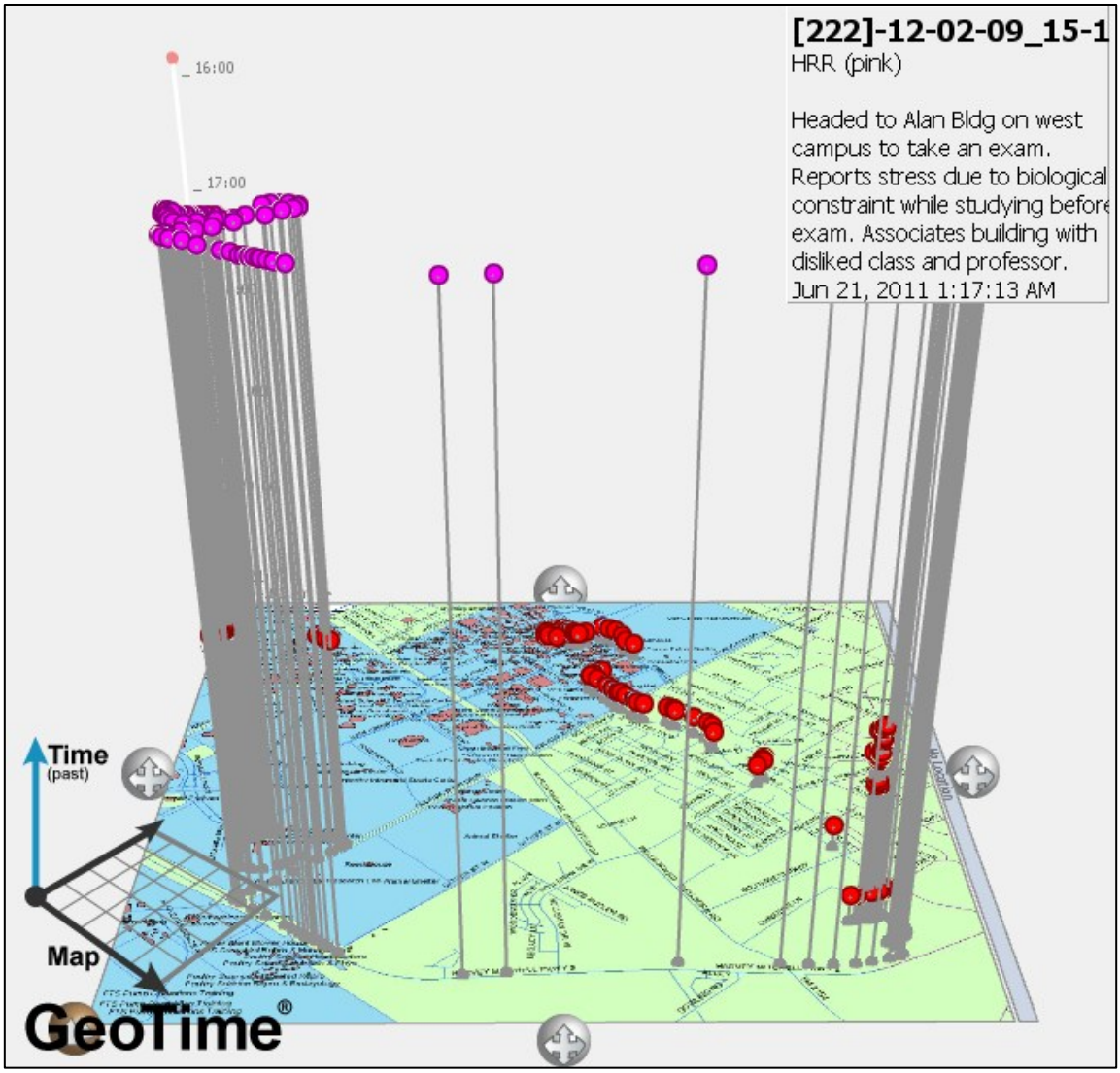



**Figure 104.** Participant 222: map of HRR events (15:00-17:00).
Note: HRR events are in pink and show the participant heading to Alan Building on west campus to study and then take an exam.

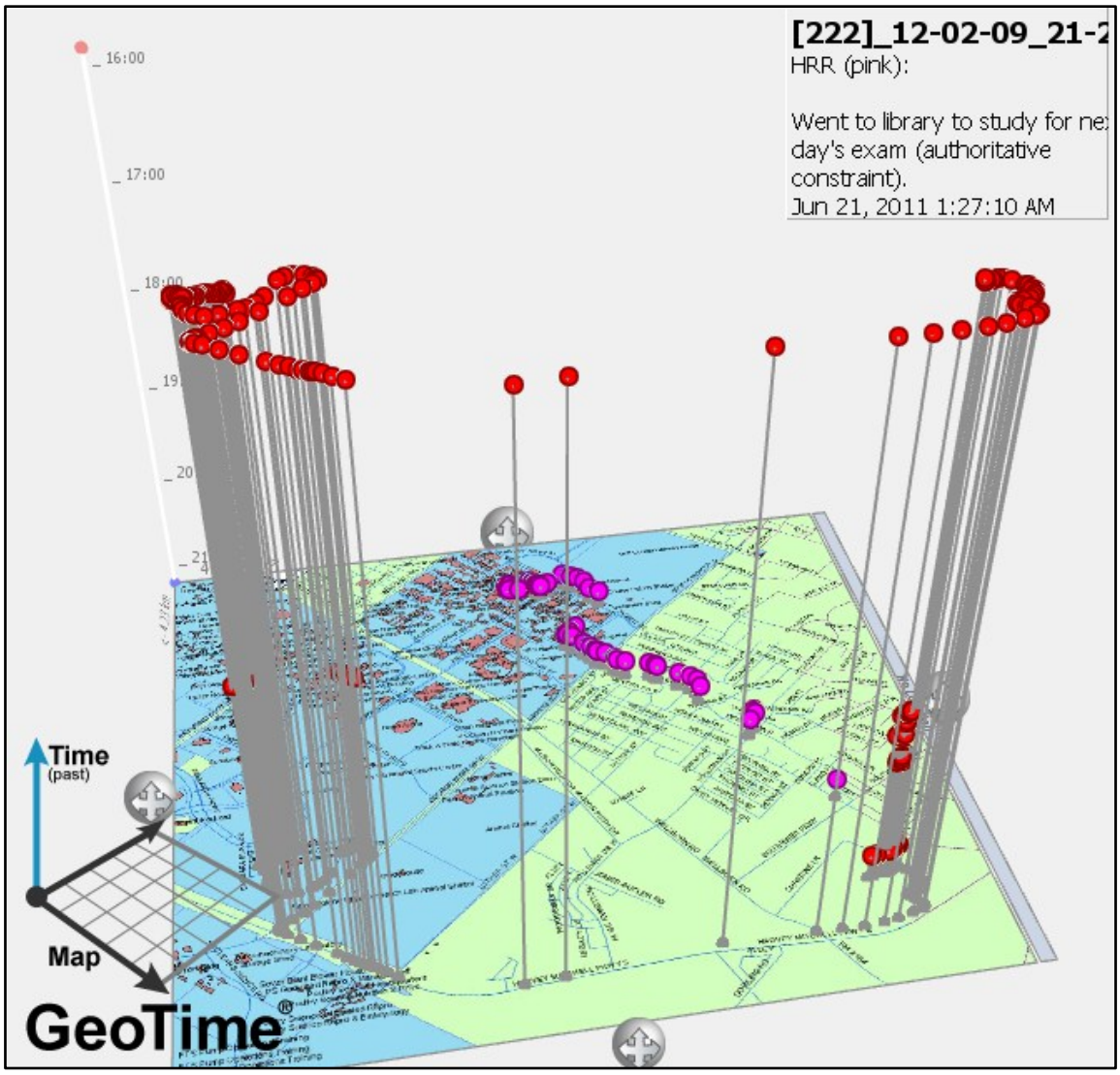



**Figure 105.** Participant 222: map of HRR events (21:00-22:00).
Note: HRR events are in pink and show the participant heading to and at the West Campus Library.

The second monitoring period was from 7:33–17:33 and the participant's audio entries dealt with academics and work. He did not discuss anything that he indicated as a stressor. *"It's about 7:45 AM. I am leaving my apartment and heading onto campus um first I have a walking class. We're not actually doing walking today. We are just going to meet with our grade and then leave and that's what I'm doing for right now"* (Entry 5: 12/08/09 @ 7:40). Walking to campus corresponded with two longer HRR events, from 7:39–7:46 (7 minutes) and 7:57–8:02 (5 minutes). *"It's now 8:15 and I'm heading to my work in the Sanders Corps Center. And I'll be here for about an hour"* (Entry 6: 12/08/09 @ 8:14). The previous audio entry matches an HRR event from 8:05–8:18 (13 minutes) while walking to his on-campus job.

After attending class the participant headed back to work at the Sanders Corps Center (Figure 106). *"It's now about a 10 a 9:20. I'm about to go to Dr. Bednarz's class in the Oceanography a Meteorology building and I will be there for about the next two hours"* (Entry 7: 12/08/09 @ 9:22). He did not report a stressor associated with the class period. *"It's now about 11 o'clock and I'm just getting back to work at the Sanders Corps Center. I will be here to about a 1:15 or so this afternoon* (Figure 107). *Work should not be stressful today I don't believe we have anything big to work on so it will be pretty relaxing; I should say pretty calm the whole time"* (Entry 8: 12/08/09 @ 10:56). The participant discussed not anticipating any stressors relating to work that day. He did experience two longer HRR events that corresponded to walking back to work and the beginning of the work period, from 10:47–10:52 (5 minutes) and 10:53–11:02 (9 minutes).

*"It's now about five o'clock in the evening. Um I just got back to my apartment and before that at 3:55 I had my last a Comm class in Harrington. It was the last day of class and he talked about how our final went and a it wasn't stressful it was more relaxing just listening to now that the class is over this is what you should have learned this is what you should've gotten out of the class. Um so if I had any stress it would just be related to activities that require other people, I guess my professor…"* (Entry 9: 12/08/09 @ 16:57). Overall the participant experienced 150 HRR episodes in this session and 22 of the events lasted 1 minute or longer.

The participant's third monitoring session lasted from 12:53–22:55. His session started with two longer HRR events that corresponded to his walking to work, from 13:04–13:10 (6 minutes) and 13:12–13:18 (6 minutes). *"Right now it's about 1:15pm. I'm currently walking to the bus stop to catch a ride to campus* (Figure 108). *I'm going to work for about three hours and I'm not sure what I'm doing after that um and that's it for now"* (Entry 10: 12/09/09 @ 13:14). He also experienced three more longer HRR events during the first hour at work, from 13:26–13:42 (6 minutes), 13:48–13:52 (4 minutes), and 13:53–13:58 (5 minutes). The participant did not provide an explanation for the indicated stress.

*"It's now 4:15 and I am leaving my work at the Sanders Corps Center and walking over to the SCC to finish up of class project for sociology* (Figure 109)*. Um it is a good thing about the project is already basically done. We have to, uh my team has to print out the final copy and um after that my stress level will go down a little bit. Um but then I'll have to start studying for finals. Anyway uh that's it for now"* (Entry 11: 12/09/09 @ 16:15). He experienced a lengthy HRR event from 16:17–16:24 (7 minutes) that corresponded to walking over to the SCC to finish a group project that is a stressor. Additionally, toward the end of working on the project he experienced an event lasting 5 minutes between 17:53–17:58. *"Um I spent the last few hours in the SCC working finishing up a project* (Figure 110) *and now when I get home I'm going to eat dinner, probably relax for little bit, and then uh start studying for a final that I have on Friday"* (Entry 12: 12/09/09 @ 18:15). In total, for this session, the participant experienced 173 HRR events, with 24 of the episodes lasting a minute or more.

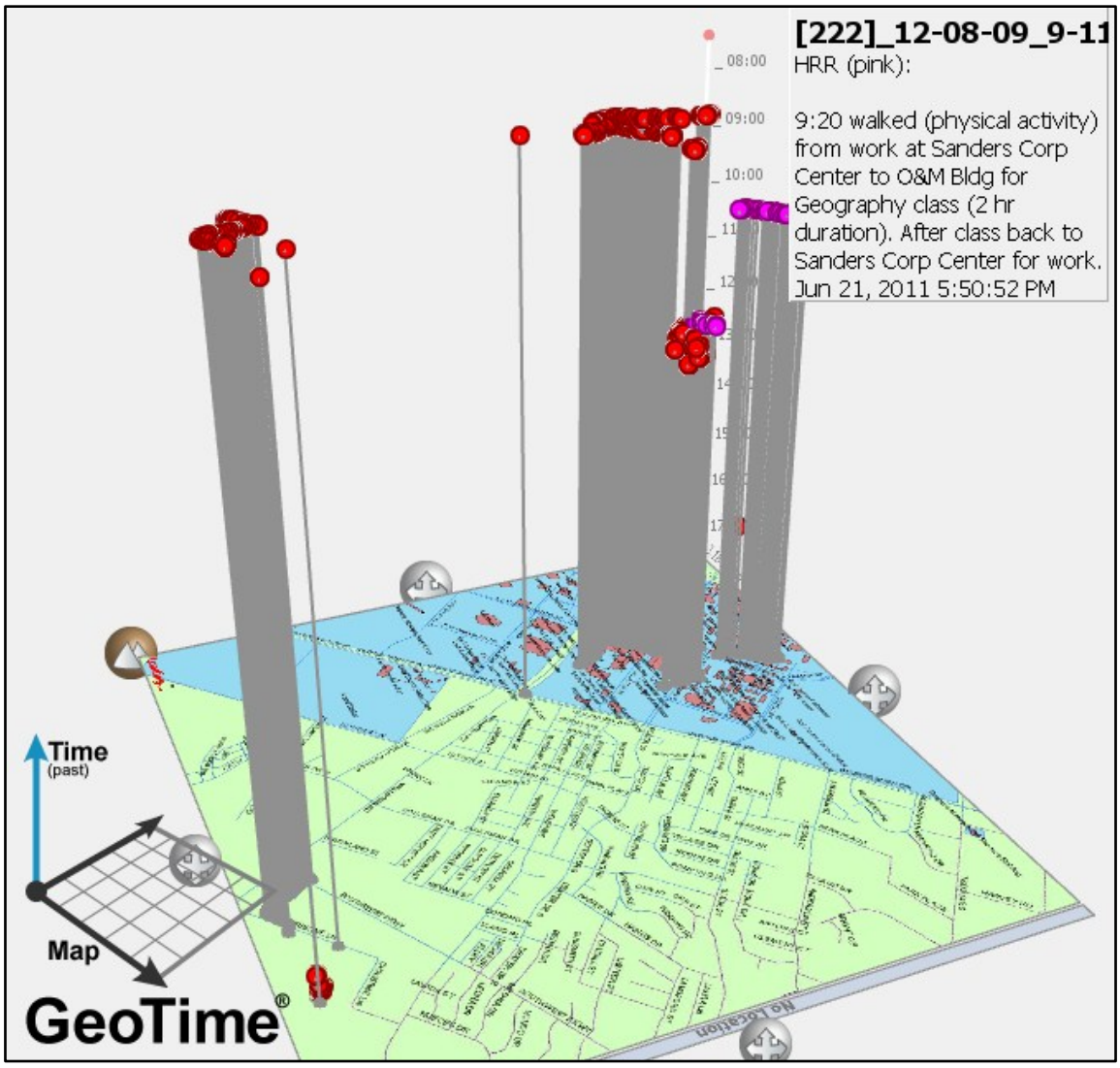



**Figure 106.** Participant 222: map of HRR events (9:00-11:00).
Note: HRR events are in pink and show the participant walking back to work and the period at the beginning of work at Sanders Corps Center.

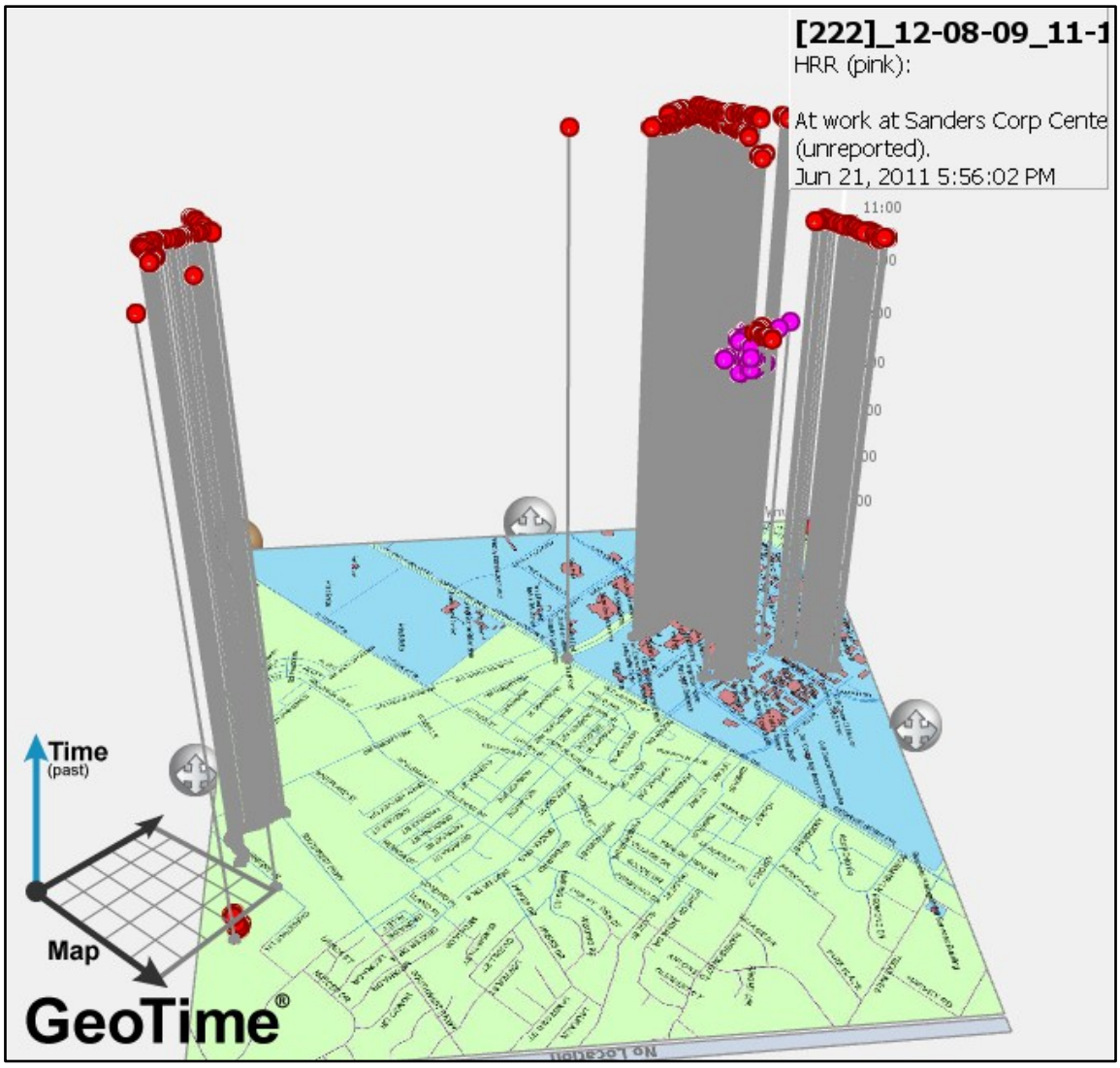



**Figure 107.** Participant 222: map of HRR events (11:00-12:00).
Note: HRR events are in pink and show the period at the beginning of the participant's work shift.

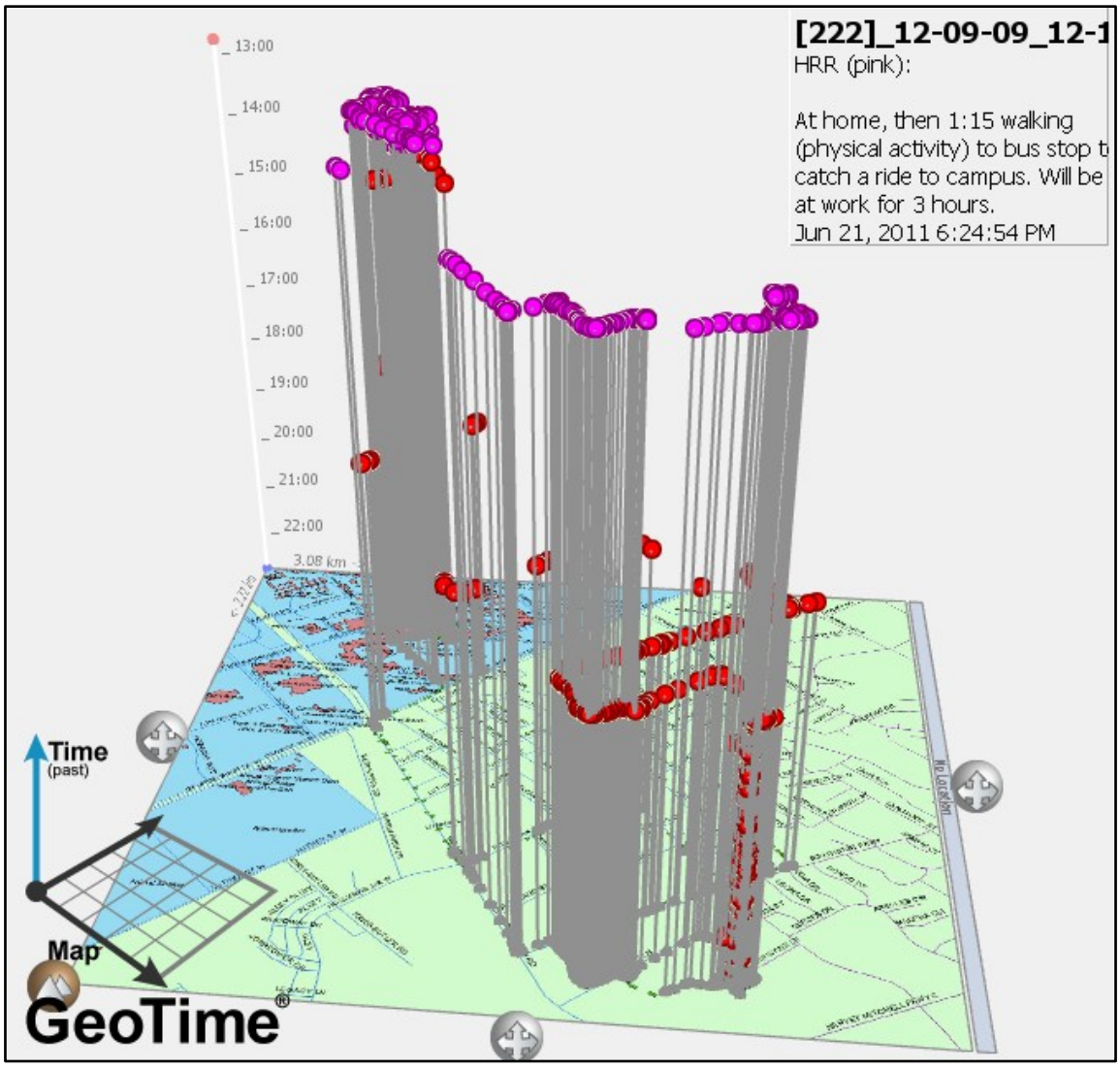



**Figure 108.** Participant 222: map of HRR events (12:00-14:00).
Note: HRR events are in pink and show the participant heading to and at work.

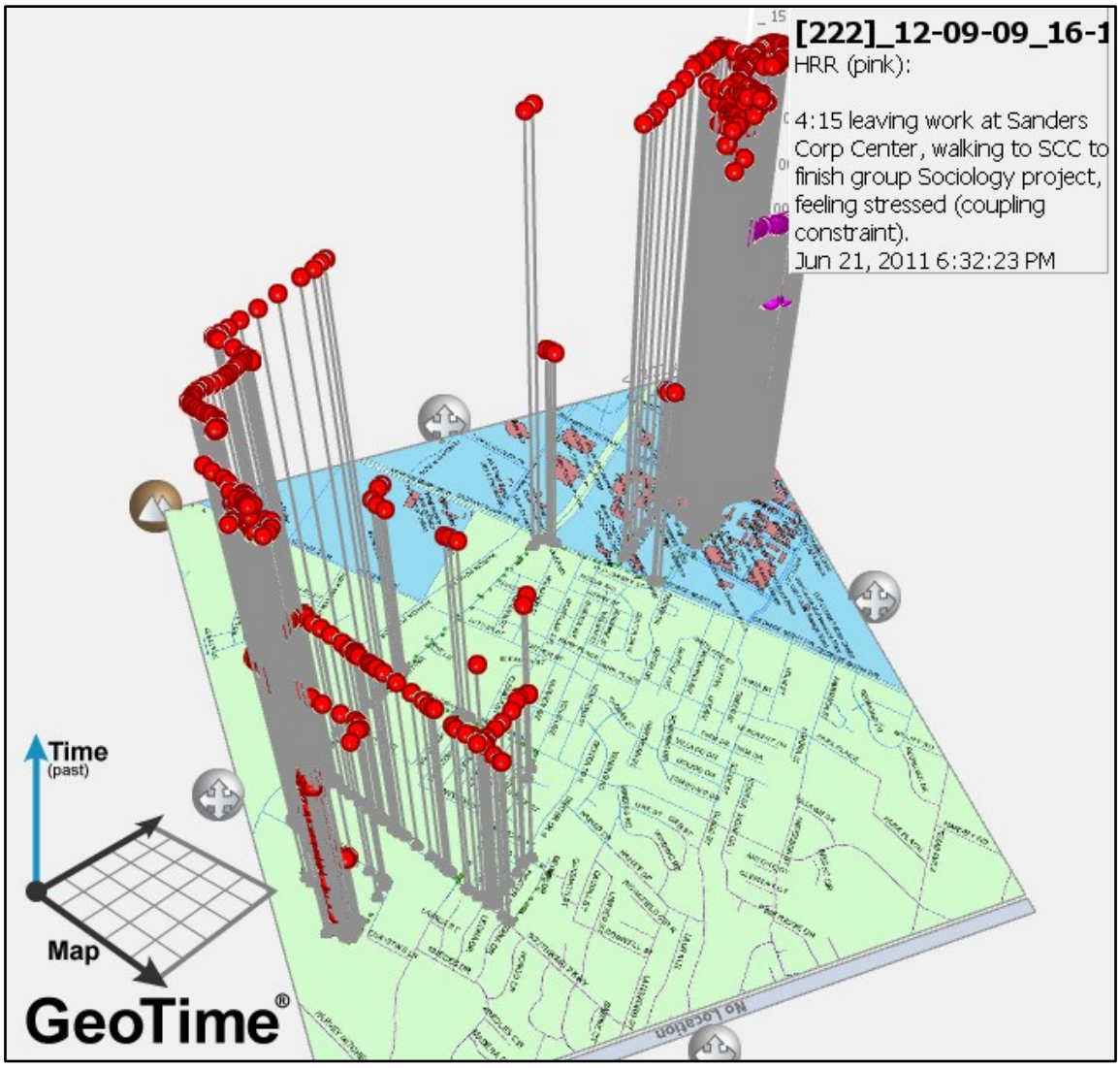



**Figure 109.** Participant 222: map of HRR events (16:00-18:00).
Note: HRR events are in pink and show the participant at the Student Computing Center (SCC) working on a group project.

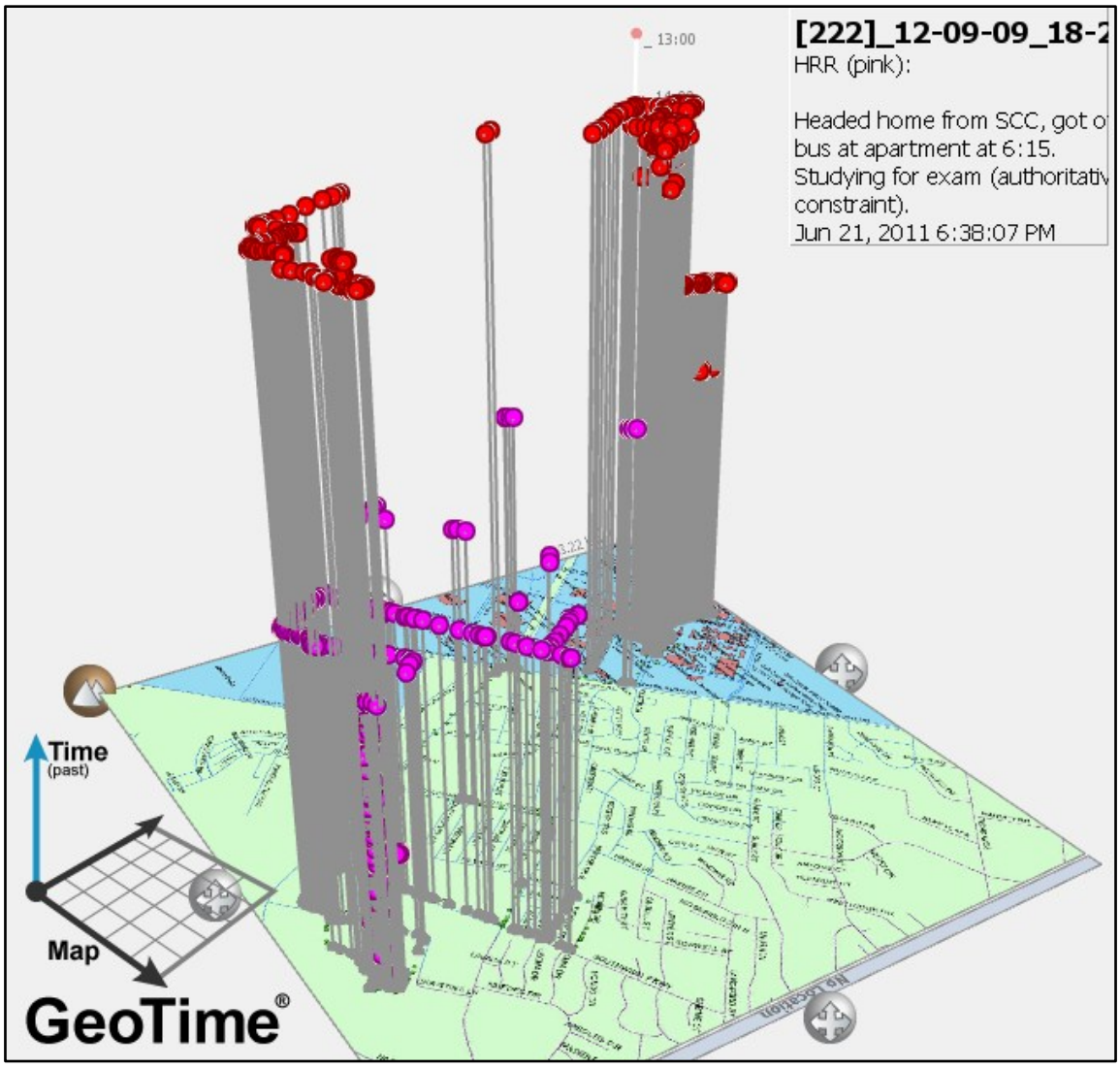



**Figure 110.** Participant 222: map of HRR events (18:00-23:00).
Note: HRR events are in pink and show the participant heading home from the SCC and at home later studying for an exam.

***Participant 223***

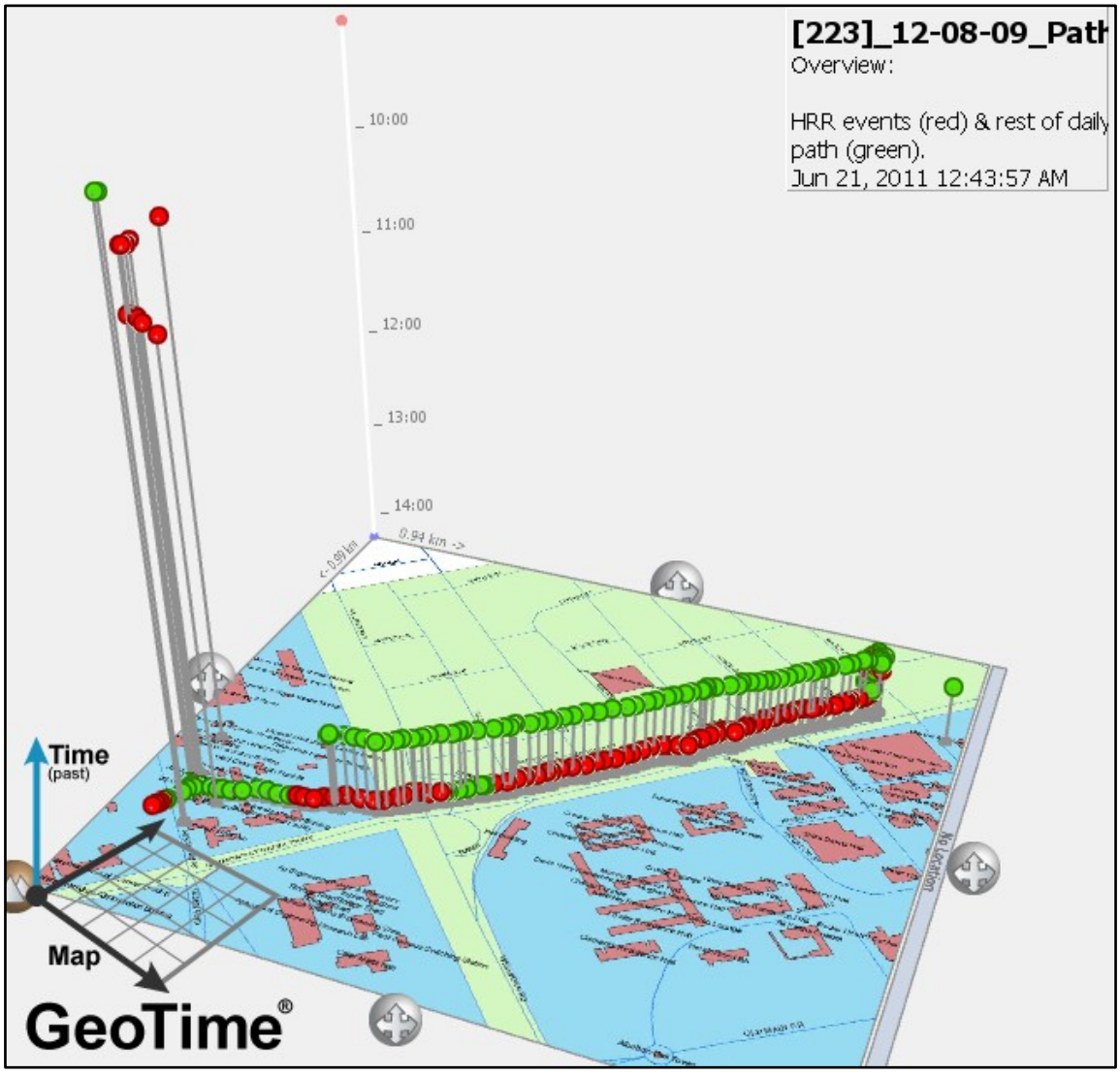



**Figure 111.** Participant 223: map of 12/08/09 daily path.
Note: HRR events are marked in red.

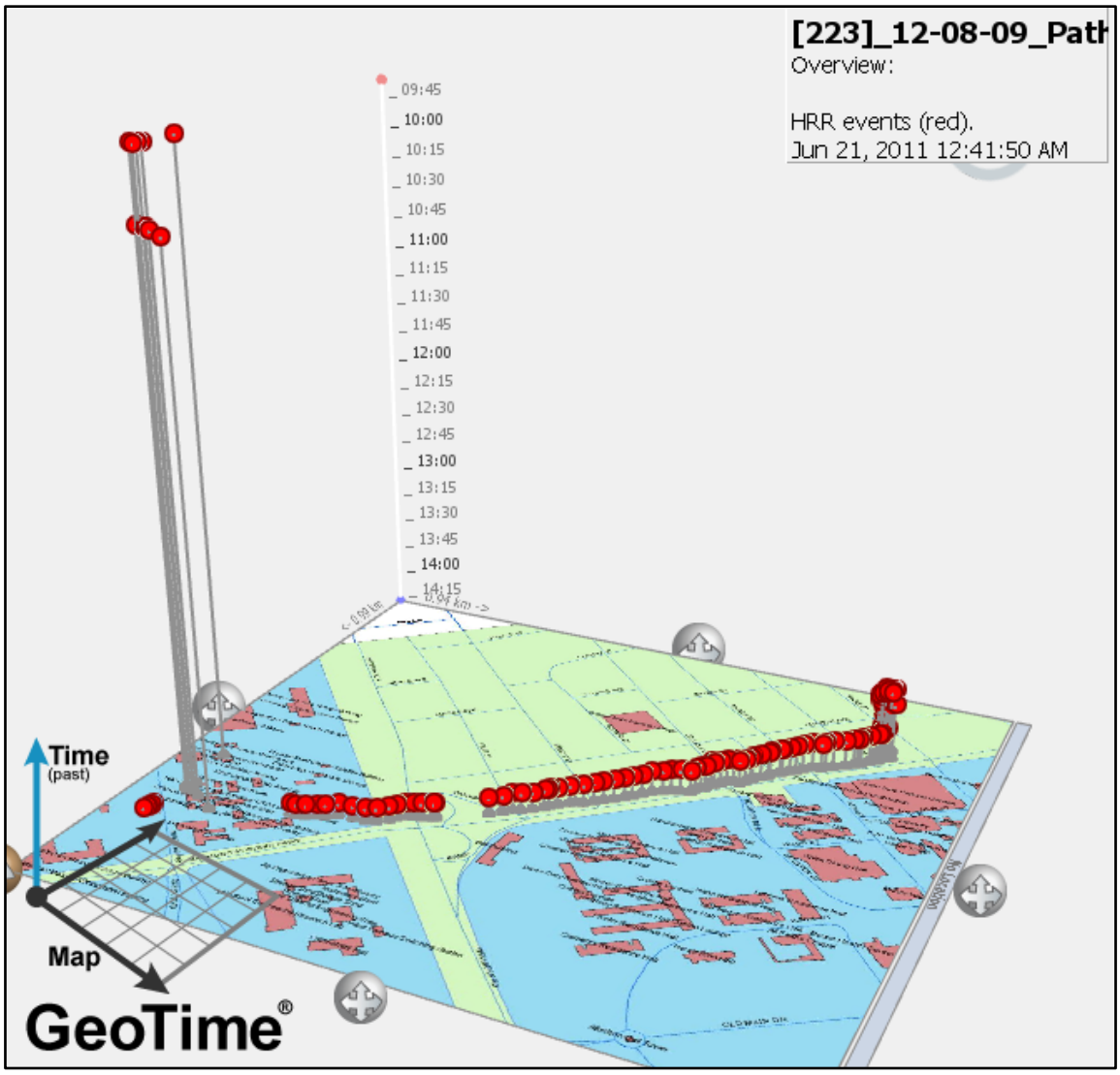



**Figure 112.** Participant 223: map of 12/08/09 logged HRR events.

In the first monitoring session (Figures 111 and 112), from 9:07–14:21, the participant noticed that the HR sensor was not consistently logging his HR. During a late lunch he fixed the equipment problem and the sensor logged his HRR episode while walking back to the lab (Figure 113). *"For the first five hour session I spent all day at work starting at about nine o'clock and going to about, let's see, nine till about two and all day at work nothing particularly eventful happened. And towards the end I was walking out to lunch and what I didn't notice was that the heart monitor wasn't really catching me too well when I was walking. So I know the heart rate was very, extremely low for that. But after I ate I think um since I was full I expanded a little bit and so it started catching it good after that* (Entry 1: 12/09/09 @ 7:56). The HRR event between 14:04–14:10 (6 minutes) corresponded to his walk back from Northgate to the Entomology lab. Overall the participant experienced ninety-six short HRR events and sixteen of them lasted 1 minute or longer.

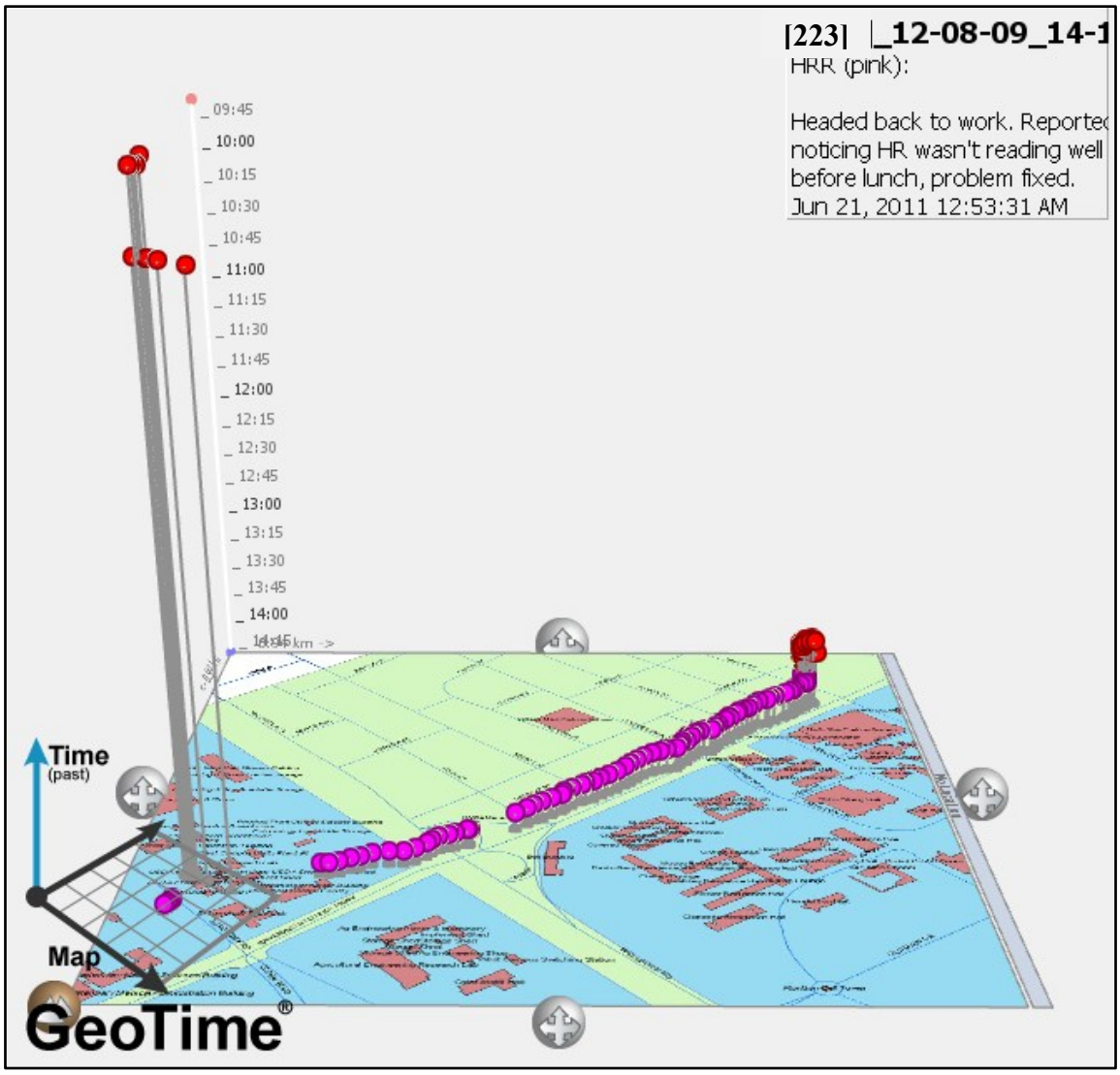



**Figure 113.** Participant 223: map of HRR events (14:00-15:00).
Note: HRR events are in pink and show the participant walking back to work after readjusting HR monitor.

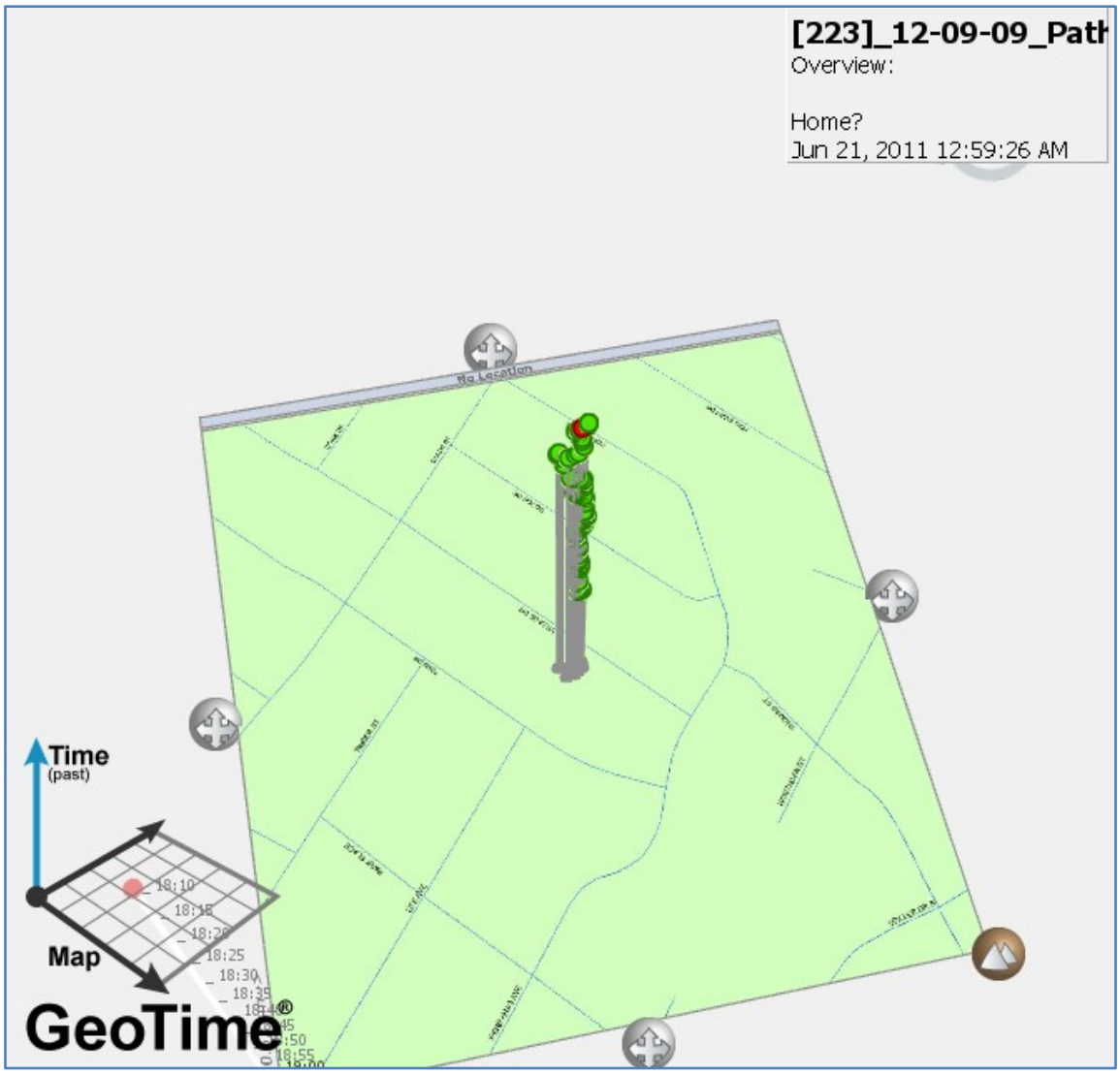



**Figure 114.** Participant 223: map of 12/09/09 daily path.
Note: HRR events are marked in red.

The participant recorded only two audio diary entries, one relating to the first session (12/8/09) and the other discussing a stressor during the second session. In the second monitoring session, it corresponded with a problem with scheduling classes for his first semester in graduate school. Between 11:45–12:45, during the time he was trying to resolve the problem, he experienced twenty-seven HRR events with six lasting 1 minute or longer. *"It's 12:30 and um I just finished probably in the past half hour I've been trying to resolve an issue with what graduate classes I'm going to take my first semester. Um ah next year I'm going to be starting grad school in the spring and uh I just couldn't find place for good times for my class. And I finally I got that resolved now…"* (Entry 2: 12/09/09 @ 14:07). In total during the day the participant experienced 150 HRR events with 14 of those lasting a minute or more.

During the third monitoring session (Figure 114), from 17:05–2:56 (12-11-09), the participant spent his time in and around what is presumed to be his home (Figures 115 and 116). He did not provide any audio entries as an explanation for logged HRR events. Overall the participant experienced 128 short HRR events with 18 episodes lasting 1 minute or longer.

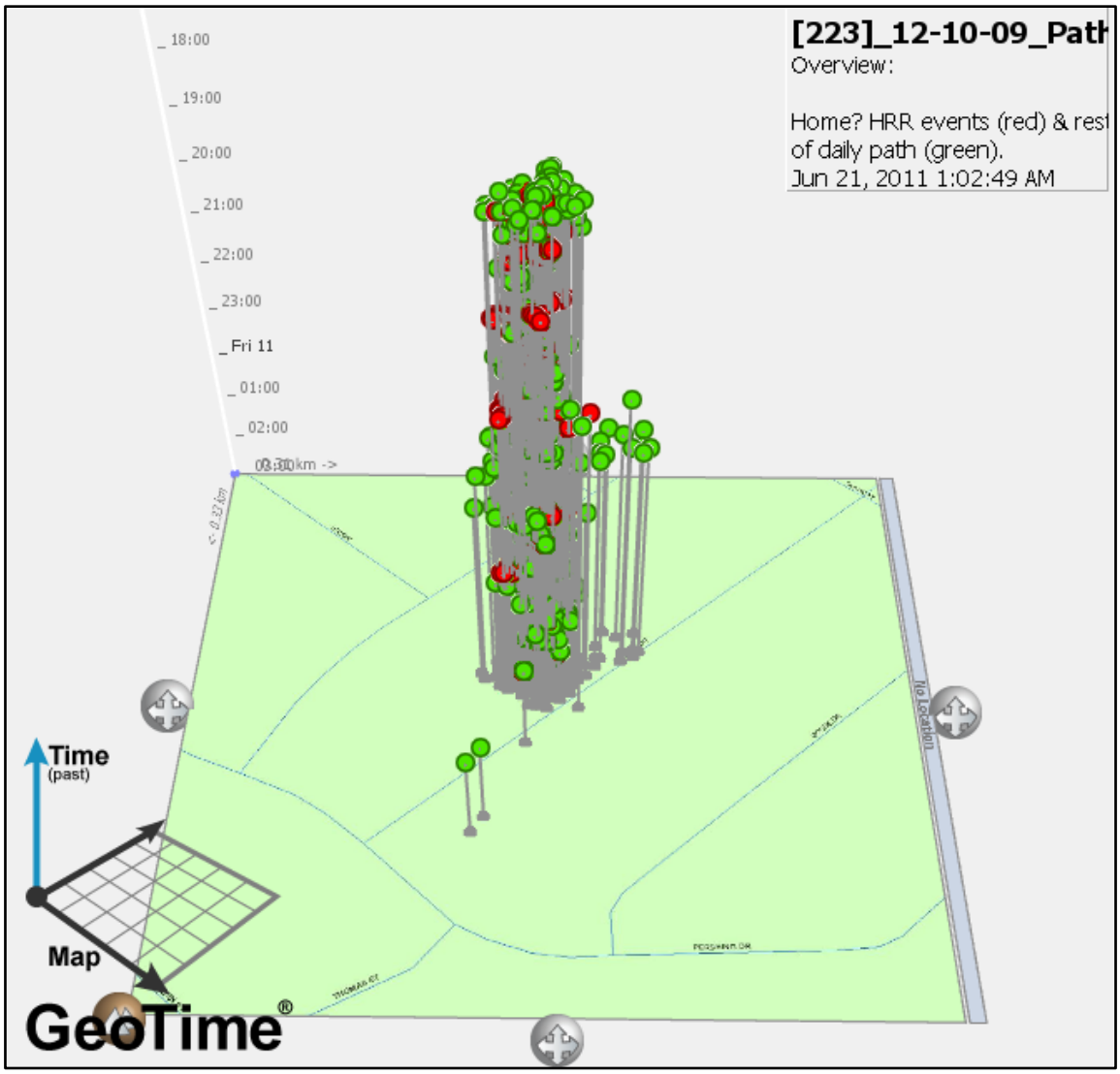



**Figure 115.** Participant 223: map of 12/10/09 daily path.
Note: HRR events are marked in red.

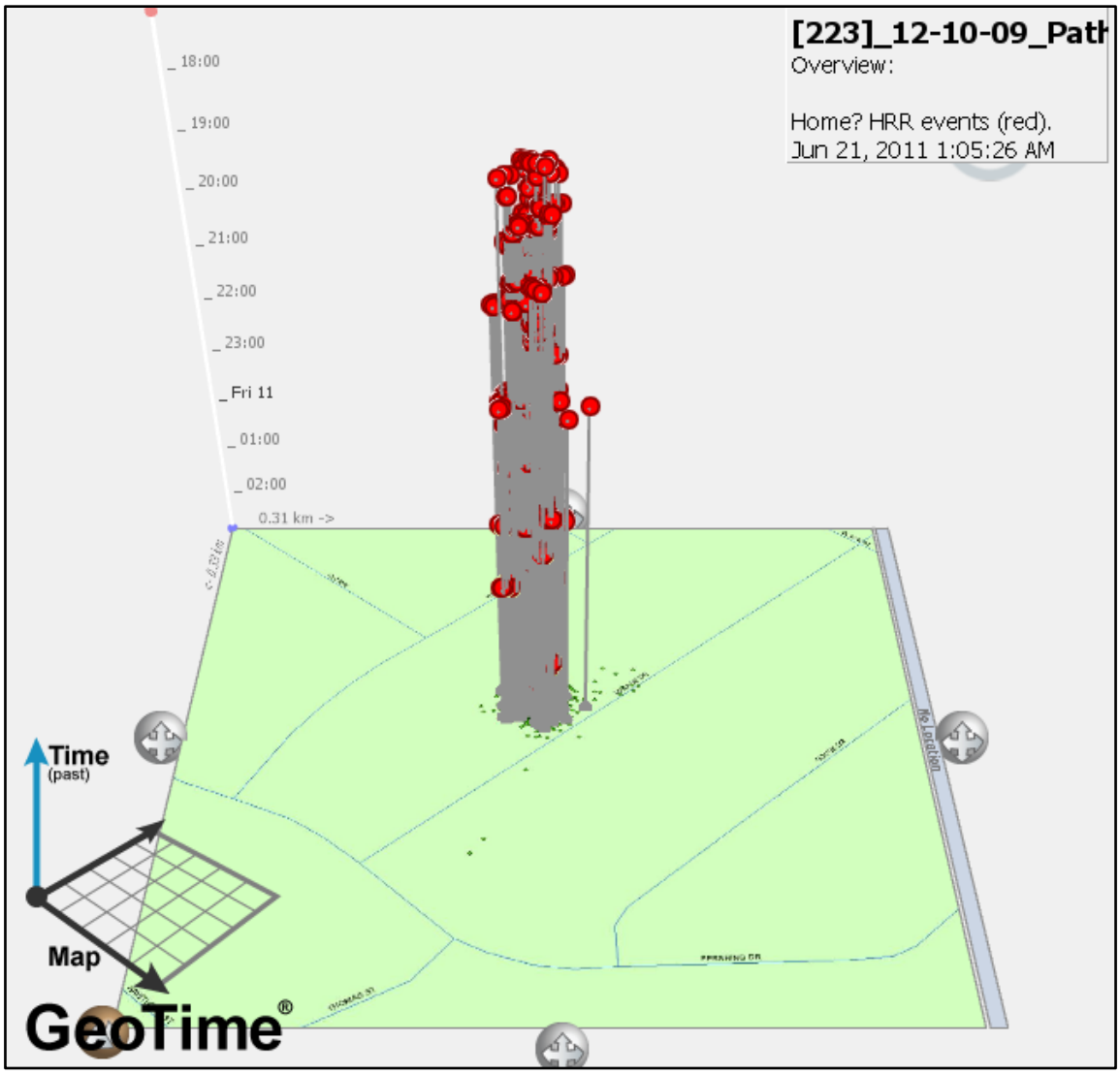



**Figure 116.** Participant 223: map of 12/10/09 logged HRR events.

## Self-Report Versus Mobile Monitoring

### *Self-Report Audio Diary and GPS/HR Matrixes*

The following tables show every entry from each participant's self-report audio diary. Information from participants 203, 205, and 214 was excluded due to missing all GPS/HR data that could be compared with audio files. Representing these results in a

graphic format makes it easy to see that the diary measure and the GPS/HR measure are discordant in some instances. Causes for the differences in measurement output are primarily related to retrospective audio accounting, missing data in the GPS and HR logs, lack of detail and resolution in audio entries, and equipment use error. The concordance tables are arranged based on the following information guidelines.

- Entry Date & Time: digital audio recorder timestamp information
- Prospective entry: is the entry reporting an event that is currently happening (just happened), yes or no
- GPS concordance: (1) yes, this entry corresponds to logged location, (2) yes, this retrospective entry can be matched to logged location, (3) no, it does not correspond to logged location, (4) no location was given in this audio entry, or (5) no location was logged by the GPS unit
- HRR concordance: (1) yes, an HRR event corresponds to this entry, (2) yes, an HRR event can be matched to this retrospective entry, (3) no, an HRR event does not correspond to this entry, or (4) no HRR event was reported in this audio entry, or (5) no HR (bpm) data were logged (within two minutes before or after timestamp/stated time)
- Brief description of the socio-environment and constraint reported by participant: [A] authoritative, [B] biological, and [C] coupling
- Expert (researcher) assignment of alternate constraint based on information in audio diary entry: [A] authoritative, [B] biological, and [C] coupling, [P] physical activity, [E] excitement, [S] stimulant, and [U] unexplained

Fifty percent of participant 201's 6 audio entries were retrospective (see Table 8). For GPS concordance two out of the three retrospective entries are category (2), an entry that was matched to a logged location and time (see Table 8). One out of the three retrospective entries is a category (4), an entry where no location was given in the audio recording. In comparison, two out of the three prospective entries gave locations but they were unable to be associated with the GPS log due to missing data for those specific times. In the case of participant 201, a third of the audio entries show a positive concordance with GPS logged locations. Both of the concordant entries were retrospectively reported.

Examining HRR concordance two out of the three retrospective entries is category (2), an entry that was matched to an HRR event (see Table 8). One out of the three retrospective entries is a category (3), no HRR event corresponds to the entry. Comparatively, the prospective entries show one corresponding entry (category 1), one entry where no associated HR data was logged (category 5), and one entry that did not report an HRR event. 50 percent of the participant's audio entries show a concordant HRR event, two of the entries were matched retrospectively, and one corresponded based on its recorded timestamp.

Twenty percent of participant 202's five audio entries were retrospective (see Table 9). Exploring GPS concordance only one retrospective entry was recorded and there was no associated GPS data logged (see Table 9). The other four audio entries were prospective but similarly, due to missing GPS data, there are no locations logged for

concordance. For participant 202's entries no concordance with GPS points was able to be established.

For HRR concordance the retrospective entry is a category (2), it was matched to an HRR event (see Table 9). Three out of the four prospective entries are category (1); corresponding to an HRR event and one entry had no associated HR data to compare it to. 80 percent of this participant's audio entries are HRR concordant.

Six percent of participant 204's sixteen audio entries are retrospective (see Table 10). For GPS concordance 62 percent of the audio entries are category (1), they directly correspond to logged GPS locations (see Table 10). The nine concordant entries are all prospective. One out of the six entries that were not in agreement with GPS logs was retrospective and all were category (5), with no associated location data.

Examining HRR concordance 87 percent of the audio diaries are category (1), they directly correspond to HRR events (see Table 10). The two entries not in agreement, of which one is retrospective, are category (5), situations where no associated HR data were logged.

Nine percent of participant 206's eleven audio entries are retrospective (see Table 11). For GPS concordance 100 percent of the entries are category (5), there is no GPS data to compare them to (see Table 11). Exploring HRR concordance 63 percent of the entries are category (1), they are concordant with recorded HRR events (see Table 11). The other four entries are either category (3), not in agreement with a calculated HRR event or category (5), having no HR data logged to associate during the account time period.

None of participant 207's seven audio entries are retrospective (see Table 12). Examining GPS concordance 100 percent of the participant's entries are category (5), there was no GPS data logged during the time frame (see Table 12). For HRR concordance 83 percent of the entries are category (1), they directly correspond to logged HRR events. One out of the six entries is a category (5), with no HR data recorded at the time.

Twenty percent of participant 208's five audio entries were retrospective (see Table 13). Exploring GPS concordance one out of five entries was GPS concordant. It is a category (2), able to be retrospectively matched with logged GPS data (see Table 13). Eighty percent, the other four entries had no GPS data for comparison.

Examining HRR concordance two out of the five entries are HRR concordant (see Table 13). One is a category (2), able to be retrospectively matched with a calculated HRR event and the other is a category (1), directly corresponding to an HRR event. Sixty percent, the other three entries, are a category (5), having no logged HR data to associate with.

None of participant 209's two audio entries were retrospective (see Table 14). Examining GPS concordance both of the participant's entries are concordant (see Table 14). They are category (1) entries, directly corresponding to logged GPS data. For HRR concordance both entries are category (3), the account does not correspond to logged HR data (see Table 14).

One hundred percent of participant 210's four audio entries were retrospective (see Table 15). For GPS concordance three out of the four entries are category (5), with no

logged GPS data to compare during the time span. One entry is a category (2), a retrospective entry that was matched to GPS data (see Table 15).

Exploring HRR concordance three out of the four entries are category (3), and were not able to be matched to logged HRR events (see Table 15). One entry is a category (2), a retrospective entry that was matched to a logged HRR event.

One hundred percent of participant 211's six audio entries were retrospective (see Table 16). Examining GPS concordance 83 percent of this participant's entries are concordant (see Table 16). These five entries are category (2); each one was retrospectively matched to a logged GPS location. One entry is a category (5), where no data were logged to associate.

For HRR concordance 83 percent of the entries are HRR concordant (see Table 16). Five out of six category (5) entries, retrospectively matched to HR logs. One entry is a category (5), with no HR data logged for comparison.

One hundred percent of participant 212's eight audio entries were retrospective (see Table 17). For GPS concordance none of this participant's entries are GPS concordant (see Table 17). The entries are category (5); no GPS data were collected during the time period.

Exploring HRR concordance 87 percent of the entries are not in agreement with logged HRR events for various reasons (see Table 17). Four entries are category (3), where the account does not correspond to logged HRR events. Two entries are category (5), having no HR data for comparison and One entry is a category (4), an instance when

the participant did not report an HRR event. The only HRR concordant entry is a category (2), retrospectively matched with a calculated HRR event.

Twenty-five percent of participant 213's four audio entries were retrospective (see Table 18). Examining GPS concordance one of the participant's entries is GPS concordant (see Table 18). It is a mixed entry including both prospective and retrospective information. The prospective part of the entry is a category (1); it directly corresponds to GPS data. The remaining three entries are category (5), with no associated GPS data.

For HRR concordance three out of the four participant entries are category (1), directly corresponding to logged HRR events (see Table 18). One of the HRR concordant entries is partially retrospective, referring to previous accounts. The entry that is not in agreement is a category (5), with no HR data collected during the time period.

Eleven percent of participant 215's nine audio entries were retrospective (see Table 19). Exploring GPS concordance none of this participant's entries are GPS concordant (see Table 19). All of the entries are category (5), with no associated GPS data logged.

For HRR concordance 100 percent of the entries are HRR concordant. All of the entries except the retrospective one are category (1), directly corresponding to recorded HR data and the retrospective entry was successfully matched to an HRR event.

None of participant 216's five audio entries were retrospective (see Table 20). Investigating GPS concordance 60 percent of this participant's entries are GPS concordant (see Table 20). These three entries are category (1), with direct

correspondence to logged GPS locations. The other two entries are category (5), having no associated GPS data logged during the time period.

Examining HRR concordance two of the five entries are HRR concordant. These two entries are category (1), corresponding to calculated HRR events. Two of the entries are category (3), with no corresponding HRR event and one entry is a category (5), with no comparative HR data recorded during the time span.

Four percent of participant 217's twenty-one audio entries were retrospective (see Table 21). For GPS concordance none of the twenty-one participant entries are GPS concordant (see Table 21). All of the entries are category (5), with no comparative GPS locations logged at the time.

Investigating HRR concordance 85 percent of the participant's entries are not in agreement with logged HR data (see Table 21). Sixty-one percent of these entries are category (5), with no HRR data recorded at the time for comparison. Thirty-nine percent of these entries are category (3), showing no correspondence to calculated HRR data. Two of the twenty-one entries are category (1), corresponding to logged HR data.

Five percent of participant 218's thirty-seven audio entries were retrospective (see Table 22). Examining GPS concordance only 11 percent of this participant's entries are GPS concordant (see Table 22). The four concordant entries are category (1), with correspondence to logged GPS locations. Eighty-nine percent of the entries are category (5), with no GPS data logged during the time period.

For HRR concordance 83 percent of the entries are HRR concordant (see Table 22). Ninety-four percent of these are category (1), with direct correspondence with logged

HRR events. Six percent of these entries are category (2), able to be retrospectively matched to HRR events. Six of the thirty-seven entries are in non-agreement with calculated HRR events. Two of these entries are category (3), not corresponding to logged HRR events and four entries are category (5), with no GPS data logged at the time.

None of participant 219's sixteen audio entries were retrospective (see Table 23). Exploring GPS concordance 87 percent of this participant's entries are not in agreement with logged GPS data (see Table 23). All of these entries are category (5), with no comparative GPS data logged at the time. Two of the sixteen entries are category (1), directly corresponding to logged GPS locations.

Investigating HRR concordance 75 percent of the entries are HRR concordant (see Table 23). The concordant entries are category (1), with correspondence to logged HRR events. Out of the non-agreement entries three are category (5), with no HR data recorded at the time and one is a category (3), with no corresponding HRR events.

Twenty-two percent of participant 220's nine audio entries were retrospective (see Table 24). Examining GPS concordance 77 percent of the entries are GPS concordant (see Table 24). Five of these are category (1); corresponding to collected GPS data and two of these are category (2), able to be retrospectively matched to logged GPS locations. Two of the entries are category (5) and are in non-agreement due to missing GPS data during the time period.

For HRR concordance 55 percent of the entries are HRR concordant (see Table 24). Three of these entries are category (1); corresponding to HRR events and two are category (2), retrospectively matched to collected HR data. Of the non-agreement entries two are category (3); with no corresponding HRR events and two are category (5), where no HR data was logged.

Eight percent of participant 221's twelve audio entries were retrospective (see Table 25). For GPS concordance 58 percent of the entries are GPS concordant (see Table 25). Of these entries six are category (1), corresponding to GPS locations and one is a category (2), retrospectively matched to logged GPS data. The other five entries do not agree with the collected GPS data. They are all category (5) entries, having no logged GPS data for comparison.

Examining HRR concordance 91 percent of the entries are HRR concordant (see Table 25). Each of the eleven concordant entries are category (1), corresponding to HRR events except the retrospective entry categorized as a (2), matched to an HRR event.

Eight percent of participant 222's twelve audio entries were retrospective (see Table 26). Exploring GPS concordance 91 percent of the entries are GPS concordant, with all of those being category (1), corresponding to GPS locations (see Table 26). One entry is a category (5), with no comparative GPS data collected at the time.

Examining HRR concordance 100 percent of the participant's entries are HRR concordant (see Table 26). The entries are all category (1), directly corresponding to logged HRR events.

Fifty percent of participant 223's two audio entries were retrospective (see Table 27). Investigating GPS concordance one of the two entries is a category (2), GPS concordant account, which was matched retrospectively (see Table 27). The other entry is a category (5), with no GPS data available for comparison.

For HRR concordance both the retrospective entry and the prospective entry are HRR concordant (see Table 27). One is a category (1), with correspondence to a calculated HRR event and the other entry is a category (2), retrospectively matched to an HRR event.

**Table 8.** Participant 201 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/10/09 19:57 | Yes | 4 & 5 | 4 | Testing audio equipment | |
| 11/11/09 10:56 | Yes | 5 | 1 | Discussing equipment issues | U |
| 11/11/09 18:21 | No | 2 | 2 | Discussing the day's events in detail | B |
| 11/12/09 9:08 | Yes | 5 | 5 | Discussing stress related to an exam, places that cause stress | A |
| 11/13/09 12:30 | No | 2 | 2 | Discussing the yesterday's events in detail | B |
| 11/16/09 6:21 | No | 4 | 3 | Discussing the day's events in detail, equipment issues | A |
| **Total = 6** | **3** | **2** | **4** | **-** | **-** |

Note: In the prospective entry column 50 percent of the audio entries were prospective and the other half were retrospective. In the GPS Concordance column two of the entries are concordant, category (2) a retrospective entry matching logged locations and the rest are either category (4), no location reported in entry or category (5), no location data logged. In the HRR Concordance column three of the entries are concordant as category (1), prospective entry matching logged HR or category (2), retrospective entry matching logged HR, one entry was a category (3), entry does not match logged HR, the other two entries are category (4), no stressor reported in entry, and category (5), no HR data logged. Socio-environmental contexts are a truncated description of entry accounts. Participant 201 discusses daily events including exam and place stressors and equipment issues. Constraints associated with stressors are two designated [A] authoritative, two [B] biological, and one [U] unexplained.

**Table 9.** Participant 202 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/11/09 7:52 | Yes | 5 | 1 | Running late for class | A |
| 11/12/09 14:58 | Yes | 5 | 1 | Noticed high HR, attributes it to illness | B |
| 11/12/09 15:05 | Yes | 5 | 1 | Climbing stairs | P |
| 11/12/09 18:10 | No | 5 | 2 | Working at the Humane Society | P |
| 11/13/09 7:47 | Yes | 5 | 5 | Running late for class | A |
| Total = 5 | 4 | 0 | 4 | - | - |

Note: In the prospective entry column four out of five entries were prospective. In the GPS Concordance column all five entries are discordant, category (5) with no location data logged. In the HRR Concordance column four entries are concordant; three are category (1), prospective entry matching logged HR and one is a category (2), retrospective entry matching logged HR. One entry is a category (5), no HR data logged. In socio-environmental contexts participant 202 discusses daily events including running late for class, illness, and work. Constraints associated with stressors are two designated [A] authoritative, one [B] biological, and two [P] physical activity.

**Table 10.** Participant 204 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/11/09 11:47 | Yes | 5 | 1 | Headed to get something to eat at Commons. | P |
| 11/11/09 12:05 | Yes | 5 | 1 | Headed to Spanish class in Civil Engineering Bldg. | P |
| 11/11/09 12:13 | Yes | 5 | 1 | In Spanish class. Quiz might cause stress. | A |
| 11/11/09 13:24 | Yes | 1 | 1 | Outside before heading to next class. Reflecting on not feeling stressed. | P |
| 11/11/09 14:55 | Yes | 1 | 1 | Leaving class in CSA, headed to a Geography study group for next 3 hours. | P |
| 11/11/09 16:48 | Yes | 1 | 1 | Finished group work and headed to write a paper later | C & P |
| 11/12/09 9:20 | Yes | 1 | 1 | Walking to class after a night of little sleep. Late for class (always late for this class). | A & B, P |
| 11/12/09 11:34 | Yes | 1 | 1 | Leaving Biology lecture headed to lunch. | P |
| 11/12/09 13:51 | Yes | 1 | 1 | At Neil Elementary School in Bryan, TX to mentor a student. | C & P |
| 11/12/09 15:30 | Yes | 1 | 1 | At the SCC writing an essay for class. Reports not feeling stressed. | A |
| 11/12/09 20:07 | Yes | 5 | 5 | Still at SCC, almost finished writing essay. Reports not feeling stressed but hungry. | |
| 11/13/09 12:30 | Yes | 5 | 1 | Walking toward O&M Bldg. Feeling some stress, lots to do today. | B & P |
| 11/13/09 16:30 | No | 5 | 5 | Accounting of day since last entry. Not stressed but excited about evening plans. | E |
| 11/13/09 19:37 | Yes | 1 | 1 | Headed to party. | E |
| 11/13/09 23:35 | Yes | 1 | 1 | Leaving one party, headed to another. Reflecting on general stress patterns and reporting that highest observed HR was 190 (soccer) and lowest was (51). | E |
| 11/14/09 00:05 | Yes | 1 | 1 | Walking to dorm. | P |
| **Total = 16** | **15** | **10** | **14** | **-** | **-** |

Note: The timestamps for this participant's entries are an hour later than the actual time they were recorded, which is corroborated by the GPS/HR log and self-reported times in the audio entries. In the prospective entry column fifteen out of sixteen entries were prospectively recorded. In the GPS Concordance column ten entries are concordant, category (1), prospective entry matching logged location. Six entries are category (5), with no location data logged. In the HRR Concordance column fourteen entries are concordant, category (1) prospective entry matching logged HR. Two entries are category (5), no HR data logged. In socio-environmental contexts participant 204 discusses daily events including running late for class, exams, classes, group assignments, mentoring, walking on campus, studying and social events. Constraints associated with stressors are two designated [A] authoritative, two [B & P] biological & physical, two [C & P] coupling & physical, one [A, B, & P] authoritative, biological, & coupling, six [P] physical activity, and one [E] excitement.

**Table 11**. Participant 206 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/15/09 16:19 | Yes | 5 | 3 | In dorm relaxing. | |
| 11/15/09 19:38 | Yes | 5 | 1 | Just woke up from nap. | U |
| 11/17/09 8:46 | Yes | 5 | 1 | Walking up stairs to class, reports feeling a little stressed. | A & P |
| 11/17/09 14:08 | Yes | 5 | 1 | About to take a nap. | P |
| 11/17/09 16:40 | Yes | 5 | 1 | Studying. | A |
| 11/17/09 18:14 | Yes | 5 | 3 | End of study period. | |
| 11/18/09 12:26 | Yes | 5 | 1 | About to take a History exam, reports stress and increased HR. | A |
| 11/18/09 15:27 | Yes | 5 | 1 | Reporting removing the GPS monitor briefly, HRR from 15:24-15:29 (5 minutes) and then a log gap until 17:23. | U |
| 11/18/09 15:49 | No | 5 | 5 | Reports neglecting to identify constraints earlier. Talking about stress and taking naps to cope. Discussing stress during study time and exam. | |
| 11/18/09 15:56 | Yes | 5 | 5 | Just cleaned dorm really fast. | P |
| 11/18/09 17:23 | Yes | 5 | 1 | Notes having forgot to start the GPS timer after putting back on 2 hours ago explains log gap. | U |
| **Total = 11** | **10** | **0** | **7** | **-** | **-** |

Note: In the prospective entry column ten out of eleven entries were prospectively reported. In the GPS Concordance column none of the entries are concordant; they are all category (5), no location data logged. In the HRR Concordance column seven of the entries are concordant as category (1) prospective entry matching logged HR. Two entries are category (3), entry does not match logged HR and two entries are category (5), no HR data logged. In socio-environmental contexts participant 206 discusses daily events including relaxing, sleeping, studying, walking around campus, stress related to exams, house cleaning, equipment issues. Constraints associated with stressors are two designated [A] authoritative, one [A & P] authoritative and physical activity, two [P] physical activity and three [U] unexplained.

**Table 12**. Participant 207 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/17/09 8:25 | Yes | 5 | 1 | Equipment issues. | U |
| 11/17/09 8:46 | Yes | 5 | 1 | Walking up stairs. | P |
| 11/17/09 15:27 | Yes | 5 | 1 | About to work out. | P |
| 11/17/09 16:19 | Yes | 5 | 1 | HR still up from workout, about to remove GPS briefly, gap in log from 16:20-16:37. | P |
| 11/17/09 16:39 | Yes | 5 | 1 | Stressed due to upcoming study group, running late, unfamiliar with people. Biological and Coupling Constraints. | |
| 11/17/09 17:08 | Yes | 5 | 1 | Headed to study group in Cambridge dorm. Anxious due to study group and exam tomorrow. Coupling Constraint. | A & C |
| 11/18/09 9:06 | Yes | 5 | 5 | Equipment issues, did not complete third monitoring session. | |
| **Total = 7** | **7** | **0** | **6** | **-** | **-** |

Note: In the prospective entry column all of the entries were prospectively reported. In the GPS Concordance column all of the entries are discordant; they are all category (5), no location data logged. In the HRR Concordance column six entries are concordant, the six entries are category (1) prospective entry matching logged HR. One entry is a category (5), no HR data logged. In socio-environmental contexts participant 207 discusses daily events including working out, study group stress, exam anxiety, equipment issues, and running late. Constraints associated with stressors are one designated [A & C] authoritative & coupling, one [B & C] biological & coupling, three [P] physical activity and one [U] unexplained.

**Table 13.** Participant 208 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/15/09 18:37 | Yes | 5 | 5 | Folding laundry. | |
| 11/15/09 19:12 | Yes | 5 | 5 | Going to take a nap. | |
| 11/17/09 14:28 | Yes | 5 | 5 | Reports having an exam tomorrow, stressed, has a lot to do today. | A & B |
| 11/17/09 14:42 | Yes | 5 | 1 | Just finished phone call concerning job interview, nervous. | A |
| 11/18/09 11:13 | No | 2 | 2 | Had exam at 9:00, stress due to lack of studying. | B |
| **Total = 5** | **4** | **1** | **2** | **-** | **-** |

Note: In the prospective entry column four out of five entries were prospectively reported. In the GPS Concordance column one entry is concordant; it is a category (2) retrospective entry matching logged location. Four entries are category (5), no location data logged. In the HRR Concordance column two entries are concordant; one is a category (1) prospective entry matching logged HR and the other is a category (2) retrospective entry matching logged HR. Three entries are category (5) no HR data logged. In socio-environmental contexts participant 208 discusses daily events including doing laundry, napping, studying, nervousness over a job interview, exam stress, and time pressures. Constraints associated with stressors are one designated [A] authoritative, one [B] biological, and one [A & B] both authoritative and biological.

**Table 14.** Participant 209 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/23/09 12:30 | Yes | 1 | 3 | Outside running around with pet. | P |
| 11/23/09 12:50 | Yes | 1 | 3 | Trying to study, procrastinating. | |
| **Total = 2** | **2** | **2** | **0** | **-** | **-** |

Note: In the prospective entry column both entries were prospectively reported. In the GPS Concordance column both entries are concordant, category (1) prospective entry matching logged location. In the HRR Concordance column neither entry is concordant, both are category (3), entry does not match logged HR. In socio-environmental contexts participant 209 discusses daily events including running outside with pets and trying to study but procrastinating instead. The associated stressor explanation is [P] physical activity.

**Table 15.** Participant 210 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/16/09 8:18 | No | 5 | 3 | Sunday 11/15/09, on bus returning from Oklahoma trip, feeling sick to stomach (stressed) due to the upcoming week, Authoritative Constraint. Argument with buddies over where to eat dinner, Coupling Constraint. Fight with friends over smoking, father has smoking related health issues. Discussion with mother regarding dad's surgery. In dorm preparing for outfit (corps) meeting, Authoritative Constraint. | |
| 11/16/09 8:20 | No | 5 | 3 | Monday 11/16/09, mandatory study hour for Corps. | |
| 11/23/09 11:47 | No | 5 | 3 | Monday 11/16/09, Corps senior hell week, dealing with yelling, on the spot commands, required buddy system, drills, getting "smoked" by seniors, etc. | A |
| 11/23/09 11:49 | No | 2 | 2 | Tuesday 11/17/09, Corps band members get together [excitement], preparing for a Chemistry exam, nervous due to still having to deal with hell week requirements. | A & E |
| **Total = 4** | **0** | **1** | **1** | **-** | **-** |

Note: In the prospective entry column none of the entries were prospective, they were all retrospectively reported. In the GPS Concordance column only one entry was concordant, it is a category (2) retrospective entry matching logged location. The other three entries are category (5), no location data logged. In the HRR Concordance column only one entry is concordant, it is a category (2) retrospective entry matching logged HR. The other three entries are category (3), entry does not match logged HR. In socio-environmental contexts participant 210 discusses daily events including studying, Corp involvement and requirements, an out of state field trip, conflict with friends, serious family issues, a band get together, and exams. Constraints associated with stressors are three designated [A] authoritative, one [C] coupling, and another as [A & E] authoritative & excitement.

**Table 16.** Participant 211 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/23/09 14:53 | No | 2 | 2 | Reports having taken 2 exams, was stressed (freaked out) over both. | A |
| 11/23/09 16:50 | No | 2 | 2 | Took Chemistry lab final, scared about grade. Took Psychology Exam, failed miserably. | A |
| 11/23/09 16:51 | No | 5 | 5 | Up until 3:00 or 4:00 Thursday and Friday studying for Biology exam. | A |
| 11/23/09 16:53 | No | 2 | 2 | Finished Biology exam, went to dinner, saw a funny movie. | A & P |
| 12/03/09 21:39 | No | 2 | 2 | In badminton tournament morning of December 2nd. | P |
| 12/03/09 21:41 | No | 2 | 2 | Geography exam Wednesday (12/2/09) evening. Reported being extremely frightened, stressed, exam was very hard. | A |
| **Total = 6** | **0** | **5** | **5** | **-** | **-** |

Note: In the prospective entry column none of the entries is prospective. They were all recorded retrospectively. In the GPS Concordance column five entries are concordant; all five are category (2) retrospective entry matching logged location. One entry is a category (5), no location data logged. In the HRR Concordance column five entries are concordant, all five are category (2) retrospective entry matching logged HR. One entry is a category (5), no HR data logged. . In socio-environmental contexts participant 211 discusses daily events including stress related to exams, playing in a badminton tournament, dinner, and social activities. Constraints associated with stressors are four designated [A] authoritative, one [A & P] authoritative & physical activity, and one [P] physical activity.

**Table 17.** Participant 212 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/19/09 18:10 | No | 5 | 5 | Reporting being stressed about an exam this morning and having little sleep. | A |
| 11/19/09 18:18 | No | 5 | 4 | Reporting that the rest of the day was stress free. | |
| 11/20/09 17:00 | No | 5 | 3 | Walking to class in the rain, stress due to exam in 20 minutes. Reports not having studied enough. Biological Constraint. | |
| 11/20/09 17:10 | No | 5 | 3 | Reporting finishing exam. Discussing stress due to biological ability and pressure from authority figures (parents) to do well in school. | A & B |
| 11/20/09 17:13 | No | 5 | 3 | Discussing getting back Chemistry lab exam with a really good grade, excited. | E |
| 11/24/09 00:02 | No | 5 | 3 | Late for class Monday morning, road bike really fast. | A & P |
| 11/24/09 00:04 | No | 5 | 2 | 15:00 Monday Geography exam, freaking out, didn't study enough. Biological Constraint. | |
| 11/24/09 00:05 | No | 5 | 5 | 19:00 Monday ran to Sbisa to get dinner, physical activity. | |
| **Total = 8** | **0** | **0** | **1** | **-** | **-** |

Note: In the prospective entry column none of the entries were prospective, all eight were reported retrospectively. In the GPS Concordance column none of the entries are concordant; all eight entries are category (5), no location data logged. In the HRR Concordance column one entry is concordant, a category (2) retrospective entry matching logged HR. Three entries are category (3), entry does not match logged HR, one entry is a category (4), no stressor reported in entry, and two entries are category (5), no HR data logged. In socio-environmental contexts participant 212 discusses daily events including exam stress, lack of sleep, walking to class, excitement over good grades, studying, and meals. Constraints associated with stressors are one designated [A] authoritative, two [B] biological, one [A & B] authoritative & biological, [A & P] authoritative and physical activity, and one [P] physical activity, and one [E] excitement.

**Table 18**. Participant 213 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/19/09 11:26 | Yes | 5 | 5 | Headed to library to study. | |
| 11/19/09 14:20 | Yes | 5 | 1 | Just walked from library to dance class. | P |
| 11/19/09 15:58 | Yes | 5 | 1 | Just arrived home from dance class. | U |
| 11/20/09 18:13 | Yes (partially) | 1 | 1 | Discussing yesterday's and today's activities. Reports being very stressed out today studying for several upcoming exams. | A |
| **Total = 4** | **4** | **1** | **3** | **-** | **-** |

Note: In the prospective entry column all four entries have prospective reporting. In the GPS Concordance column only one entry is concordant, a category (1) prospective entry matching logged location. The other three entries are category (5), no location data logged. In the HRR Concordance column three of the entries are concordant, all three are category (1) prospective entry matching logged HR. One entry is a category (5), no HR data logged. In socio-environmental contexts participant 213 discusses daily events including studying, walking on campus, dance class and stress related to exams. Constraints associated with stressors are one designated [A] authoritative, one [P] physical activity and one [U] unexplained.

**Table 19.** Participant 215 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/19/09 22:36 | Yes | 5 | 1 | In apartment stressed out studying for an exam the last 45 minutes. | A |
| 11/19/09 23:40 | Yes | 5 | 1 | In apartment playing soccer video game. | E |
| 11/20/09 13:58 | No | 5 | 2 | Reporting stressful meeting with advisor regarding class schedule. | A |
| 11/20/09 16:01 | Yes | 5 | 1 | At apartment doing laundry, reports lots of things to do right now. | B |
| 11/20/09 18:35 | Yes | 5 | 1 | At apartment just finished laundry and cleaning. | P |
| 11/23/09 11:24 | Yes | 5 | 1 | At apartment cramming for quiz, quiz in 2 hours. Reports stress as Biological Constraint. | A & B |
| 11/23/09 13:40 | Yes | 5 | 1 | Running late for class. | A & P |
| 11/23/09 14:21 | Yes | 5 | 1 | At school studying for exam being given in 2 hours, stressed. | A & B |
| 11/23/09 16:58 | Yes | 5 | 1 | Just finished exam, walking to apartment. | P |
| **Total = 9** | **8** | **0** | **9** | **-** | **-** |

Note: In the prospective entry column eight out of nine entries were reported prospectively. In the GPS Concordance column none of the entries are concordant; all nine entries are category (5), no location data logged. In the HRR Concordance column all nine entries are concordant, eight entries are category (1) prospective entry matching logged HR and one entry is a category (2) retrospective entry matching logged HR. In socio-environmental contexts participant 215 discusses daily events including exam stressors, walking around campus, running late for class, cleaning, studying, time pressure, meeting with advisor, and playing video games. Constraints associated with stressors are two designated [A] authoritative, one [B] biological, two [A & B] authoritative & biological, one [A & P] authoritative and physical activity, two [P] physical activity and one [E] excitement.

**Table 20.** Participant 216 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/19/09 10:51 | Yes | 1 | 1 | Chemistry final. | A |
| 11/19/09 14:30 | Yes | 1 | 1 | Working out. | P |
| 11/19/09 18:53 | Yes | 1 | 3 | Studying for Biology exam. | A |
| 11/20/09 9:16 | Yes | 5 | 3 | In room resting, going to Chemistry class soon. | |
| 11/20/09 11:45 | Yes | 5 | 5 | Studying for Biology exam, test later in the day. | A |
| **Total = 5** | **5** | **3** | **2** | **-** | **-** |

Note: In the prospective entry column all five entries are prospective. In the GPS Concordance column three entries are concordant; all three are category (1) prospective entry matching logged location. Two entries are category (5), no location data logged. In the HRR Concordance column two entries are concordant, they are both category (1) prospective entry matching logged HR. Two entries are category (3), entry does not match logged HR and one is a category (5), no HR data logged. In socio-environmental contexts participant 216 discusses daily events including exams, studying, class, working out and resting. Constraints associated with stressors are three designated [A] authoritative and one is [P] physical activity.

**Table 21.** Participant 217 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/20/09 10:44 | Yes | 5 | 5 | In dorm preparing for day, about to study Biology. | |
| 11/20/09 12:03 | Yes | 5 | 5 | Headed to lunch at Sbisa. | P |
| 11/20/09 12:39 | Yes | 5 | 3 | Studying in dorm. | |
| 11/20/09 14:29 | Yes | 5 | 3 | Headed to Biology exam in Heldenfels. | P |
| 11/20/09 15:56 | Yes | 5 | 5 | Done with first monitoring session. | |
| 11/21/09 13:19 | Yes | 5 | 5 | Headed to game at Kyle Field. | P |
| 11/21/09 18:30 | Yes | 5 | 5 | Back from game, headed to eat. | P |
| 11/21/09 20:01 | Yes | 5 | 5 | In dorm. | |
| 11/21/09 21:04 | Yes | 5 | 5 | Just worked out. | P |
| 11/21/09 23:23 | Yes | 5 | 5 | Sitting. End of second monitoring session. | |
| 11/23/09 10:14 | Yes | 5 | 1 | Studying for Geography exam. | A |
| 11/23/09 10:35 | Yes | 5 | 1 | About to take a nap. | A |
| 11/23/09 11:01 | Yes | 5 | 3 | Studying for exam again. | |
| 11/23/09 11:56 | Yes | 5 | 5 | Headed for lunch. | P |
| 11/23/09 12:35 | Yes | 5 | 5 | Studying for exam again. | |
| 11/23/09 14:29 | Yes | 5 | 5 | Headed for Biology class in Heldenfels. | P |
| 11/23/09 17:03 | No | 5 | 2 | After Biology class took Geography exam in Zachary Bldg. (15:53). Reports feeling stressed due to Biological constraint. Walked back to dorm at 16:53. | A & B |
| 11/23/09 17:24 | Yes | 5 | 3 | Outside sitting in grass. | |
| 11/23/09 18:14 | Yes | 5 | 3 | Eating dinner. | |
| 11/23/09 18:52 | Yes | 5 | 3 | In dorm. | |
| 11/23/09 20:14 | Yes | 5 | 3 | In dorm. End of third monitoring session. | |
| **Total = 21** | **20** | **0** | **3** | **-** | **-** |

Note: In the prospective entry column twenty out of twenty-one entries were reported prospectively. In the GPS Concordance column all twenty-one entries are discordant; each entry is a category (5), no location data logged. In the HRR Concordance column three of the entries are concordant; two are category (1) prospective entry matching logged HR and one is a category (2) retrospective entry matching logged HR. Seven entries are category (3), entry does not match logged HR and eleven are category (5), no HR data logged. In socio-environmental contexts participant 217 discusses daily events including exam stress, studying, walking around campus, napping, class, sitting outside, and meals. Constraints associated with stressors are two designated [A] authoritative, one [A & B] authoritative & biological, and seven [P] physical activity.

**Table 22.** Participant 218 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/19/09 17:26 | Yes | 5 | 1 | Excited, just picked up research equipment, walking fast. | E & P |
| 11/19/09 21:02 | Yes | 5 | 1 | Just returned from the Vice President of Education's dinner, was a little nervous. | A & C |
| 11/19/09 21:02 | Yes | 5 | 1 | Correcting a point from last entry. | U |
| 11/19/09 21:56 | Yes | 1 | 1 | Leaving meeting at Rudder Tower, walking to dorm. | P |
| 11/19/09 22:01 | Yes | 1 | 1 | In Briggs dorm. | U |
| 11/19/09 22:08 | Yes | 5 | 5 | Equipment issue. | |
| 11/19/09 22:15 | No | 5 | 2 | Looking over audio diary instructions, hasn't been following them correctly. Vice President's dinner was Authoritative Constraint, later meeting was Coupling Constraint. | |
| 11/19/09 22:17 | Yes | 5 | 3 | Sitting in the dorm hallway. | |
| 11/19/09 22:22 | Yes | 1 | 1 | Walking back to dorm room. | P |
| 11/19/09 22:22 | Yes | 1 | 1 | Reports Biological Constraint. | |
| 11/19/09 22:29 | Yes | 5 | 1 | End of first monitoring session. | U |

**Table 22.** Continued

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/20/09 11:17 | Yes | 5 | 5 | In dorm preparing for class. | |
| 11/20/09 12:16 | Yes | 5 | 1 | Just finished talking to boyfriend for the last 15 minutes or so. | C |
| 11/20/09 12:32 | Yes | 5 | 1 | In Blocker. | U |
| 11/20/09 12:41 | Yes | 5 | 1 | Reports being mad. | C |
| 11/20/09 12:41 | Yes | 5 | 1 | Is mad at boyfriend. | C |
| 11/20/09 14:40 | Yes | 5 | 1 | Walking outside in the rain. | P |
| 11/20/09 14:52 | Yes | 5 | 1 | In dorm room in Briggs. | U |
| 11/20/09 15:12 | Yes | 5 | 1 | In dorm room. | U |
| 11/20/09 17:26 | Yes | 5 | 1 | Walking to Sbisa to meet people from high school. | C & P |
| 11/20/09 21:19 | Yes | 5 | 1 | Walking back to dorm. | P |
| 11/20/09 21:24 | No | 5 | 2 | In dorm, took off equipment to charge. Reports the student board (high school) as a Coupling Constraint. | |
| 11/23/09 11:19 | Yes | 5 | 1 | Just turned on GPS unit. | U |
| 11/23/09 11:19 | Yes | 5 | 1 | In Briggs dorm room. | U |
| 11/23/09 12:32 | Yes | 5 | 5 | Inside Blocker. | |
| 11/23/09 12:51 | Yes | 5 | 3 | Reports Biological Constraint, didn't study for exam or read for class. | |
| 11/23/09 15:26 | Yes | 5 | 1 | In library studying from 14:45 – 15:25, head hurts. Reports Biological Constraint, self-imposed stress. | |
| 11/23/09 15:47 | Yes | 5 | 1 | In class, head hurts, haven't studied for exam. | B |

**Table 22.** Continued

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 11/23/09 15:47 | Yes | 5 | 1 | Reports not having eaten, being on period, and being mad. | B |
| 11/23/09 16:33 | Yes | 5 | 1 | Reports finishing exam and thinking that it went well, still has headache. | P |
| 11/23/09 16:45 | Yes | 5 | 1 | In Briggs dorm room. Reports Biological Constraint. | |
| 11/23/09 18:21 | Yes | 5 | 1 | Male voice talking in background. | P |
| 11/23/09 18:22 | Yes | 5 | 1 | At Fusion Fiesta. Reports Biological Constraint, might have a fever and walking fast. | B & P |
| 11/23/09 20:49 | Yes | 5 | 1 | Leaving Fusion Fiesta, reports excitement and Coupling Constraint. | |
| 11/23/09 21:18 | Yes | 5 | 1 | In Briggs dorm room, studying for Geology exam. | A |
| 11/23/09 21:18 | Yes | 5 | 1 | Refers to last entry as Biological Constraint. | |
| 11/23/09 22:04 | Yes | 5 | 5 | End of monitoring. | |
| **Total = 37** | **35** | **4** | **31** | **-** | **-** |

Note: In the prospective entry column thirty-five out of thirty-seven entries were prospectively reported. In the GPS Concordance column four entries are concordant; all four are category (1) prospective entry matching logged location. Thirty-three are category (5), no location data logged. In the HRR Concordance column thirty-one entries are concordant, twenty-nine are category (1) prospective entry matching logged HR and two are category (2) retrospective entry matching logged HR. Two entries are category (3), entry does not match logged HR and four are category (5), no HR data logged. In socio-environmental contexts participant 218 discusses daily events including conflict, walking around campus, social activities, class, equipment issues, exams, studying, class, and physical ailments. Constraints associated with stressors are two designated [A] authoritative, seven [B] biological, six [C] coupling, one [A & C] authoritative & coupling, one [B & P] biological & physical activity, one [C & P] coupling and physical activity, one [P & E] physical activity & excitement, six [P] physical activity, and eight [U] unexplained.

**Table 23.** Participant 219 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 12/1/09 18:36 | Yes | 5 | 1 | In dorm resting. | U |
| 12/1/09 20:04 | Yes | 5 | 1 | In dorm. Studying for Geography exam for next 30 minutes. | A |
| 12/1/09 22:08 | Yes | 5 | 1 | Just finished studying, stressful. | A |
| 12/1/09 22:15 | Yes | 5 | 1 | Back from vending machines, cold outside. | P |
| 12/2/09 10:32 | Yes | 5 | 1 | Overslept, stressed out. Equipment issues. Biological Constraint. | A & B |
| 12/2/09 12:27 | Yes | 1 | 1 | Just out of Computer Science class, took quiz, didn't know answers. Biological Constraint. | |
| 12/2/09 13:53 | Yes | 5 | 1 | Studying for past 45 minutes, will study till 15:00. | A |
| 12/2/09 14:33 | Yes | 5 | 5 | Removing GPS unit briefly, log gap 14:32-14:52. | |
| 12/2/09 15:58 | Yes | 5 | 5 | In Geography bldg., about to take exam. | A |
| 12/2/09 18:08 | Yes | 1 | 1 | Headed to review session, late, causing stress. | B |
| 12/2/09 20:15 | Yes | 5 | 5 | Equipment battery died; gap 18:39-21:39. | |
| 12/2/09 21:39 | Yes | 5 | 3 | In room relaxing. | |
| 12/3/09 01:06 | Yes | 5 | 1 | Went outside for snack, cold, ran back. | P |
| 12/3/09 13:24 | Yes | 5 | 1 | In Chemistry class, reports stress due to Authority Constraint. | |
| 12/3/09 16:40 | Yes | 5 | 1 | In Commons basement relaxing. | A & U |
| 12/3/09 19:19 | Yes | 5 | 1 | In Commons basement, reports trying to register for classes 20 minutes ago, stressed because of system malfunction. Authoritative and Biological Constraints. | |
| **Total = 16** | **16** | **2** | **12** | **-** | **-** |

Note: In the prospective entry column 100 percent of the entries were prospectively reported. In the GPS Concordance column two entries are concordant; category (1) prospective entry matching logged location. Fourteen entries are category (5), no location data logged. In the HRR Concordance column twelve entries are concordant; category (1) prospective entry matching logged HR. One entry is a category (3), entry does not match logged HR and three entries are category (5), no HR data logged. In socio-environmental contexts participant 219 discusses daily events including exams, studying, class, working out and resting. Constraints associated with stressors are five designated [A] authoritative, two [B] biological, two [A & B] authoritative & biological, one [A & U] authoritative & unexplained, two [P] physical activity, and one [U] unexplained.

**Table 24.** Participant 220 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 12/1/09 20:58 | Yes | 5 | 5 | Testing equipment. | |
| 12/2/09 14:31 | Yes | 1 | 3 | Equipment issues. Sitting on couch. | |
| 12/2/09 18:29 | Yes | 5 | 5 | Had a big argument with boyfriend, gap in log 18:20-20:55. | C |
| 12/3/09 7:58 | Yes | 1 | 1 | (7:46) had to run for the bus. Late, walking to class, stressed, can't have any more absences. | A & P |
| 12/3/09 10:43 | Yes | 1 | 3 | In class. | |
| 12/3/09 11:53 | No | 2 | 2 | At 11:00 had a meeting with honors council. Reports Authoritative Constraint. Headed home around 11:30. | |
| 12/3/09 17:43 | No | 2 | 2 | Woke up at 15:55, had an exam at 15:55, stressed. Ran to bus and class in Harrington. Struggled to finish due to being late, exam lasted till around 17:15. | A & P |
| 12/4/09 13:27 | Yes | 1 | 1 | Driving to Wal-Mart in Bryan. Stressed due to other drivers. Reports Coupling Constraint. | |
| 12/4/09 16:55 | Yes | 1 | 1 | Going to work. | A |
| **Total = 9** | **7** | **7** | **5** | **-** | **-** |

Note: In the prospective entry column seven out of nine entries were prospectively reported. In the GPS Concordance column seven entries are concordant; five are category (1) prospective entry matching logged location and two are category (2) retrospective entry matching logged location. Two entries are category (5), no location data logged. In the HRR Concordance column five entries are concordant; three are category (1) prospective entry matching logged HR and two are category (2) retrospective entry matching logged HR. Two entries are category (3), entry does not match logged HR and two are category (5), no HR data logged. In socio-environmental contexts participant 220 discusses daily events including work, driving, running late, exam stress, running, studying, class, personal relationship issues, honor council allegations, and equipment issues. Constraints associated with stressors are two designated [A] authoritative, two [C] coupling and two [A & P] authoritative & physical activity.

**Table 25.** Participant 221 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 12/2/09 13:06 | Yes | 1 | 1 | Headed to Weiner for lunch and then to class. Will be studying in between classes for a Geography exam at 16:00. | P |
| 12/2/09 15:56 | Yes | 1 | 1 | Headed to Geography exam, feeling stressed. | A & P |
| 12/2/09 16:39 | Yes | 1 | 1 | Just left exam, feeling relieved. It's cold outside. | P |
| 12/2/09 16:54 | Yes | 1 | 1 | In dorm exercising. | P |
| 12/3/09 9:47 | Yes | 5 | 1 | Starting second monitoring session. In dorm. Reports having an Economics exam at 14:20, a little stressed about it. | A |
| 12/3/09 14:00 | Yes | 5 | 1 | Headed to Economics exam, nervous about getting a good grade. Reports cramming for exam in dorm for past 50 minutes. | A |
| 12/3/09 15:09 | Yes | 5 | 1 | Leaving exam, didn't do well. Disappointed but relieved course is over. | P |
| 12/3/09 16:54 | Yes | 5 | 1 | Headed to meet friend, excited. | E |
| 12/4/09 8:56 | Yes | 5 | 5 | Walking to Thompson Hall for work, last day fun and games, excited. | E |
| 12/4/09 12:48 | Yes | 1 | 1 | It's snowing. Running around, really excited. | E & P |
| 12/4/09 13:38 | Yes | 1 | 1 | In Weiner, going to Accounting class. Might discuss exam, which would cause a little nervousness. | A |
| 12/4/09 17:44 | No | 2 | 2 | Eating dinner. Was playing sports for the past two and a half hours. | P |
| **Total = 12** | **11** | **7** | **11** | **-** | **-** |

Note: In the prospective entry column eleven out of twelve entries were reported prospectively. In the GPS Concordance column seven entries are concordant; six are category (1) prospective entry matching logged location and one is a category (2) retrospective entry matching logged location. Five entries are category (5), no location data logged. In the HRR Concordance column eleven entries are concordant; ten are category (1) prospective entry matching logged HR and one is a category (2) retrospective entry matching logged HR. One entry is a category (5), no HR data logged. In socio-environmental contexts participant 221 discusses daily events including exam stress, exercising, studying, class, working, games, playing sports, walking around campus, and running in the snow. Constraints associated with stressors are three designated [A] authoritative, one [A & P] authoritative & physical activity, one [P & E] physical activity & excitement, five [P] physical activity, and two [E] excitement.

**Table 26.** Participant 222 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 12/02/09 15:53 | Yes | 1 | 1 | Leaving apartment headed to Alan Bldg. on West campus to study for an 18:00 exam. Stressing about exam. | A |
| 12/02/09 16:10 | Yes | 1 | 1 | In Alan Bldg. to study for 2 hours, reports stress as Biological Constraint. Discusses stress related to being in the bldg. where exam will be, associates bldg. class, doesn't like class or professor. | A & B |
| 12/02/09 18:02 | Yes | 1 | 1 | About to take exam, stress level high, nervous. Reports accidentally turning off GPS for last 30 minutes, log gap 17:10-17:46. | A & B |
| 12/02/09 20:46 | Yes | 1 | 1 | At apartment for last half hour, ate, took online quiz, mostly relaxing. Headed to West Campus Library to study. | A |
| 12/08/09 7:40 | Yes | 1 | 1 | Headed to campus for walking class. Not actually doing walking today. | P |
| 12/08/09 8:14 | Yes | 1 | 1 | Headed to Sanders Corp Center for work, will work for an hour. | P |
| 12/08/09 9:22 | Yes | 1 | 1 | About to head to O&M Bldg. for Geography class, 2 hour class. | P |
| 12/08/09 10:56 | Yes | 1 | 1 | Back at work (Sanders Corps Center) until 13:15. | A |
| 12/08/09 16:57pm | Yes (partially) | 1, 5 | 1, 2 | Just arrived at apartment. At 15:55 had Comm class in Harrington. | U |
| 12/09/09 13:14 | Yes | 1 | 1 | Walking to bus stop. Going to work for 3 hours. | P |
| 12/09/09 16:15 | Yes | 5 | 1 | Leaving work at Sanders Corps Center, walking to SCC to finish project. Team to print final copy, some stress. | C & P |
| 12/09/09 18:15 | Yes | 1 | 1 | Walking back to apartment. Will start studying later. | A & P |
| **Total = 12** | **12** | **11** | **12** | **-** | **-** |

Note: In the prospective entry column 100 percent of the entries were reported prospectively. In the GPS Concordance column eleven entries are concordant; all eleven are category (1) prospective entry matching logged location. One entry is a category (5), no location data logged. In the HRR Concordance column all twelve entries are concordant; all of the entries are category (1) prospective entry matching logged HR. In socio-environmental contexts participant 222 discusses daily events including exams, studying, class, working out and resting. Constraints associated with stressors are three designated [A] authoritative, two [A & B] authoritative & biological, one [A & P] authoritative and physical activity, one [C & P] coupling and physical activity, four [P] physical activity, and one [U] unexplained.

**Table 27.** Participant 223 self-report audio diary and GPS/HR concordance

| Entry Date & Time | Prospective Entry | GPS Concordance | HRR Concordance | Self-reported Socio-environ and Constraint | Assigned Alternate Constraint |
|---|---|---|---|---|---|
| 12/09/09 7:56 | No | 2 | 2 | Tuesday 12/8/09, walking to and from lunch. | P |
| 12/09/09 14:07 | Yes | 5 | 1 | Frustrated, problems resolving next semester's class schedule. | A |
| **Total = 2** | **1** | **1** | **2** | **-** | **-** |

Note: In the prospective entry column one entry is prospective and the other is retrospective. In the GPS Concordance column one entry is concordant, a category (2) retrospective entry matching logged location and the other is a category (5), no location data logged. In the HRR Concordance column both entries are concordant, one is a category (1) prospective entry matching logged HR and the other is a (2) retrospective entry matching logged HR. In socio-environmental contexts participant 223 discusses daily events including work, walking around campus, and academic frustrations. Constraints associated with stressors are one designated [A] authoritative and the other one is [P] physical activity.

**Concordance Analyses: Audio/Heart Rate Reactivity**

The previous section covering the self-reported audio and GPS/HR matrixes interprets each participant's accounts in relation to the monitored data. Unlike the correlation coefficient analysis results reported below, the matrix results above take into account data missing from the GPS/HR logs. Specifically, categories (4) and (5) in the matrixes represent missing data. Since data does not exist for categories (4) and (5), excluding them from correlation analysis is a justifiable way to find associations within data that does exist.

Kendall's tau-b correlation coefficient and Spearman's rho correlation coefficient statistics were performed to analyze the self-report audio diary and heart rate data collected from each participant. The Spearman's rho statistic was employed to corroborate the Kendall's tau-b output because the latter coefficient is relatively insensitive to large discrepancies in the data (Pagano and Gauvreau 2000, Urdan 2005). Each statistic was run on HR data designated as category (1) corresponds to logged data, (2) retrospectively matched to logged data, and (3) does not correspond to logged data HRR events only. Heart Rate data designated as category (4) no event reported or (5) no data logged HRR episodes were considered missing and excluded because there was no data to correlate. The correlation statistics were performed with two-tailed tests of significance at a minimum of 95 percent confidence levels.

The chosen correlation coefficients were used to evaluate the level of concordance using category (1), (2), and (3) HRR episodes that were self-reported by participants and logged by the HR monitor. In performing these calculations the primary goal is to see if

the stress exposures reported by participants match up with the time/HR data logged by the monitoring equipment. Results (see Table 28) are included for all participants with the exception of participants 203, 205, and 214 due to their lack of monitored data. For audio/HR concordance in this study a perfect correlation denotes that prospective or retrospective audio entries of HRR match the HR logs.

In the case of participant 201 both Kendall's tau-b and Spearman's rho return a low correlation coefficient of 0.167 with a p value of 0.739 for Kendall's tau-b and 0.789 for Spearman's rho (see Table 28). The p = 0.739 and p = 0.789 means that there is a high probability of obtaining the 0.167 coefficient for the sample (N = 5) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan 2005). Concordance between the data collection methods is low for participant 201.

Participants 202 (N = 4), 204 (N = 14), 206 (N = 9), 207 (N = 6), 208 (N =2), 209 (N = 2), 211 (N = 5), 212 (N = 5), 213 (N = 3), 215 ( N = 9), 220 (N = 7), 221 (N = 11), 222 N = 12), and 223 (N = 2) have correlation coefficients of 1.000 with a p value of 0.000 for both Kendall's tau-b and Spearman's rho statistics (see Table 28). Concordance between the data collection methods is perfect for these participants.

In the case of participant 210 both Kendall's tau-b and Spearman's rho return a low correlation coefficient of 0.333 with a p value of 0.564 for Kendall's tau-b and 0.667 for Spearman's rho (see Table 28). The p = 0.564 and p = 0.667 means that there is a medium level probability of obtaining the 0.333 coefficient for the sample (N = 4) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000;

Urdan 2005). Concordance between the data collection methods is low for participant 210.

Participant 216 had both Kendall's tau-b and Spearman's rho return a mid-level correlation coefficient of 0.577 with a p value of 0.317 for Kendall's tau-b and 0.423 for Spearman's rho (see Table 28). The p = 0.317 and p = 0.423 means that there is a relatively low probability of obtaining the 0.577 coefficient for the sample (N = 4) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan 2005). Concordance between the data collection methods is medium for participant 216.

In the case of participant 217 both Kendall's tau-b and Spearman's rho return a high correlation coefficient of 0.802 (N = 10) with a p value of 0.016 for Kendall's tau-b and 0.005 for Spearman's rho (see Table 28). The coefficient is statistically significant at 0.05, the 95 percent confidence interval for Kendall's tau-b and at 0.01, the 99 percent confidence interval for Spearman's rho (see Table 28). Concordance between the data collection methods is very high to statistically significant levels for participant 217.

Participant 218 had both Kendall's tau-b and Spearman's rho return a low negative correlation coefficient of -0.117 with a p value of 0.510 for Kendall's tau-b and 0.518 for Spearman's rho (see Table 28). The p = 0.510 and p = 0.518 means that there is a medium probability of obtaining the -0.117 coefficient for the sample (N = 33) by chance or due to random error (Morgan and Griego 1998; Pagano and Gauvreau 2000; Urdan 2005). A slight negative correlation (Urdan 2005) is displayed in this participant's data indicating a modest trend for HRR episodes to appear in the HR logs and HRR events occurring in the HR logs to be connected to audio entries that did not report a stressful experience. Concordance between the data collection methods is negligible for participant 218.

In the case of participant 219 both Kendall's tau-b and Spearman's rho return a mid-level correlation coefficient of 0.409 (N = 13) with a p value of 0.156 for Kendall's tau-b and 0.165 for Spearman's rho (see Table 28). Concordance between the data collection methods is medium for participant 219.

**Table 28.** Correlation coefficients relating reported stress exposures to category (1) HRR events

| Participant | tau-b (significance) | rho (significance) | Entries |
|---|---|---|---|
| 201 | 0.167 (p = 0.739) | 0.167 (p = 0.789) | N = 5 |
| 202 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 4 |
| 204 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 14 |
| 206 | 1.000** (p = 0.000) | 1.000** (p = 0.000) | N = 9 |
| 207 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 6 |
| 208 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 2 |
| 209 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 2 |
| 210 | 0.333 (p = 0.564) | 0.333 (p = 0.667) | N = 4 |
| 211 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 5 |
| 212 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 5 |
| 213 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 3 |
| 215 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 9 |
| 216 | 0.577 (p = 0.317) | 0.577 (p = 0.423) | N = 4 |
| 217 | 0.802* (p = 0.016) | 0.802** (p = 0.005) | N = 10 |
| 218 | -0.117 (p = 0.510) | -0.117 (p = 0.518) | N = 33 |
| 219 | 0.409 (p = 0.156) | 0.409 (p = 0.165) | N = 13 |
| 220 | 1.000** (p = 0.000) | 1.000** (p = 0.000) | N = 7 |
| 221 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 11 |
| 222 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 12 |
| 223 | 1.000 (p = 0.000) | 1.000 (p = 0.000) | N = 2 |

Note: *. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

**Concordance Analyses: Audio/GPS**

Kendall's tau-b and Spearman's rho correlation coefficient statistics were performed to analyze the self-report audio diary and GPS data collected from each participant. Each statistic was run on GPS data designated as category (1) corresponds to logged data, (2) retrospectively matched to logged data, and (3) does not correspond to logged locations. GPS data designated as category (4) no location reported or (5) no GPS data logged were considered missing and excluded because there was no data to correlate. The correlation statistics were performed with two-tailed tests of significance at a minimum of 95 percent confidence levels.

The chosen correlation coefficients were used to evaluate the level of concordance using category (1), (2), and (3) location data that were self-reported by participants and logged by the GPS unit. In performing these calculations the primary goal is to see if the location of stress exposures reported by participants match up with the time/GPS data logged by the equipment. Results include participants 201, 204, 208, 209, 210, 213, 216, 217, 219, 220, 221, 222, and 223. Data for participants 202, 206, 207, 211, 212, 215, and 218 were excluded because there was no GPS data recorded during audio entry time spans or no location was given for comparison. For audio/GPS concordance in this study a perfect correlation denotes that prospective or retrospective audio entries of stress exposure locations match the GPS logs.

Statistical output for the thirteen participants with sufficient GPS logs reveal correlation coefficients of 1.000, perfect concordance between their self-reported audio accounts and logged GPS locations. The sample size, number of useable entries, for each

participant ranged between N = 1 and N = 11, and the coefficients did not register statistical significance. All audio entries that report locations with concurrent GPS data are concordant.

# CHAPTER V

# DISCUSSION

The purpose of this or any research is to find answers by using the data collected in the course of investigation to better understand the phenomena of interest. An integral part of constructing this research was determining what was important to know about how student stress relates to cognitive appraisal of the socio-environment. Closely associated to formulating research questions to probe the student stress exposure experience was how to go about measuring stress and cognitive appraisal in the field. Technological developments provided the measurement tools but raised the question of their resolution feasibility. This discussion of results examines the research findings by returning to the three original lines of inquiry as well as addressing other areas of interest.

## Feasibility of Methodology

When assessing the feasibility of the methods used in this research project for detecting stressful episodes in the field, both strengths and weaknesses were found. Overall, the majority of stressful events discussed by the participants were detected when the GPS/HR monitoring equipment was functioning optimally. On occasions when the heart rate sensors were not making sufficient contact to log beats per minute participant audio diaries often discussed the duration and severity of the event. At times there were HRR events logged by the equipment that had no explanations in the audio

diaries. Many of these turned out to be instances of physical activity, such as walking on campus, but others were unreported and did not have a spatial pattern or accompanying geographic information to discern their nature. For example, when a participant's entries said little more than they were at home relaxing, it was nearly impossible to provide an explanation for recorded HRR events. Any number of activities or situations could be the origin of unreported HRR; a few possibilities are sexual activity, playing video games, cleaning house, playing with a pet, studying, thinking about things that needed to be done, a contentious telephone conversation, cooking dinner—the list is endless.

One modification that could strengthen this type of approach is a self-report measure that reduces or eliminates retrospective reporting. Because of the three-pronged data collection approach of GPS, HR, and audio diaries, some retrospective accounts were able to be matched to the logged data, but other entries that provided less detail, including lack of temporal and geographic information, could not be reconciled. With the exception of equipment use problems, the GPS/HR measure worked as intended by tracking geographic locations and bpm of the participants as they went through their day. Future studies requiring prospective socio-environmental information could benefit from protocols used in ecological momentary assessment (EMA) studies (Cohen, Kessler, and Gordon 1997) in which participants are prompted via a PDA or other device to make entries at given times. Even using an EMA-like adjustment would still not completely address the fact that stressors do not occur on a schedule, and therefore simply prompting an entry at certain times would not necessarily resolve the issue of retrospectively reporting events. The issue could be addressed by a texting protocol that

would allow participants to discreetly make an entry in most situations or by an application that synchronizes with the GPS/HR monitor and prompts for an entry when an individual's HR reaches a predetermined number.

**Effectiveness of Time Geography Approach**

Is the time geography perspective effective for discerning field stress exposures? Yes, time geography is an effective approach for discerning stress exposures in the field. Concordance tables and statistics showed a high correlation between students' reporting stressful experiences and the monitoring equipment capturing periods of elevated heart rate. Correlation coefficients between the audio entries and category (1) logged HRR for 75 percent of the participants were 1.000 (see Table 28). Limitations have less to do with operationalizing the theory of time geography than with user error, equipment malfunctions, and the cost effective evolution of mobile bio-monitoring technology. An example of user error was participant 223 noticing that his HR sensor strap was not making adequate and consistent contact with his skin in order to log his heart rate.

Based on the lack of correlation between the SSI psychometric and the ambulatory measure of HRR the geographic perspective appears to expand the current parameters of stress exposure assessment. Mobile bio-monitoring gives an automatic and therefore objective valuation of events as opposed to a static measurement which depends primarily on subjective written responses to a limited set of generic questions regarding stress situations (Gunderson 1974; Robotham 2008). The objective field monitoring is contextualized and augmented by the associated stress exposure narratives.

Can the model of Hagerstrandian constraints (authoritative, biological, and coupling) explain factors associated with college student stress? The model of Hagerstrandian constraints in the time geography perspective is effective with regard to discerning student stress exposures in the field. Although the constraint categories were originally meant to explain the limitations or parameters on an individual's geographic travel range, they fit well in the landscape of student stress exposure. The SSI uses the stressor type categories of frustration, conflict, pressure, changes, and self-imposed. Using the Hagerstrandian constraints, authority (A) encompasses pressure, biological (B) includes self-imposed and frustration, and coupling (C) covers conflict. The SSI category of changes can fit into any of the three constraints depending on the situation it is derived from. Furthermore, when dealing with the origin of stressors or conditions that generate a stress response, three other explanations were included: physical activity, excitement, and stimulants.

Participants did not always explicitly use the A, B, and C designations to explain their stressors, but the majority of the audio diary entry explanations fit well into one of the three constraints or conditions involving physical activity, excitement, or the ingestion of a stimulant. An example of constraints fitting experiences is participant 210, *"After cleaning the bus and running upstairs with my buddies and I left the dorms to decide about dinner, which turned into an argument as always 'C' stress factor."* A group decision turns into a disagreement and is defined as a coupling constraint. Or, when participant 212 laments that, *"I have an exam in 20 minutes and I don't think I studied enough even though I probably could not have studied any more. So the stress I feel is*

*probably a limitation of my own biological ability."* The biological constraint category covers what she sees as her own shortcoming.

The SSI survey does suggest a link with the self-reported stressor constraint data. Pressure and self-imposed, which are two of the SSI stressor type categories (Appendix G), show the highest percent scores in this sample. Pressure rated high as a stressor among the students and is equivalent to the Hagerstrandian authoritative constraint. In the coding analysis academic concerns and the authoritative constraint ranked high among the factors related to stress exposures. Self-imposed also scored high values as a stressor and correlates to Hagerstrand's biological constraint. Additionally, the majority of stressors categorized with a constraint in the participant audio entries were labeled as either biological (a lack in capability), or authoritative, due to externally (professor, parent, job, or academic) imposed expectations and/or responsibilities.

Previous studies of student stress using traditional psychometrics have reached similar results regarding frequently identified sources of student stress. Academic stressors are a central theme; studying (Bush, Thompson, and Van Tuvegren 1985; Abouserie 1994; Harvey, Drew, and Smith 2006; Robotham et al 2008), examinations (Abouserie 1994; Robotham 2008), anticipation of exams (Gadzella, Masten, and Stacks 1998; Robotham 2008), and the time pressure associated with meeting deadlines or accomplishing assigned tasks (Misra et al. 2000; Robotham 2008). Students report that they often feel overwhelmed by academic requirements (Reisberg 2000; Robotham 2008) highlighting an inability to control time (Macan et al. 1990; Nonis et al. 1998; Robotham 2008) eliciting a fear of failure (Schafer 1996; Robotham 2008).

**Spatiotemporal Influences and Expressions of Stress**

Are the instances of stress in an individual student's life associated with specific locations or a chronological sequence of locations? Do an individual's stressors have a temporal/locational pattern? How does an individual's perception of place influence his or her stress level? From the combined explanatory power of GPS/HR monitoring and self-report audio diaries, it is evident that both specific locations and chronological sequences of locations traversed in an individual's daily path are factors in the experience of stress.

Several of the participants took time to discuss particular places where they experience stress and why those places have an effect on them. Participant 222, *"...possibly there maybe a little bit environmental stress a just from being in this building because I associate the building with the class that I don't like."* And, participant 201 said, *"To me Heldenfels it's taking um it's not a location anymore, it's not just a point on a map, it's a place. Um it's the place where I'll be taking my test and so it's taken a little bit more meaning that building. You know it's oh my gosh the building that I have to go in to take a biology test....Heldenfels that was just like like I really wanted to get out of that place as soon as I finished the test."*

Much of the stress-related place meaning was explained in light of the courses taken in particular buildings. It seems that for some students if they dislike the class, find the class difficult or overwhelming, or have negative feelings toward the instructor, the place where the class is held is linked to the onset of anxious or stressful feelings. In the matrix generalizing representative parts of each student narrative (see table 7) there is

more evidence to support academic places and concerns as key contributors to stressors. The socio-environmental contexts that were referred to as stressful in the majority of the twenty narratives directly involve school. Eighty-five percent of the participants experienced stress around exams and 60 percent reported stress when studying or thinking about tasks that they had to complete. Time pressure, which has been a primary factors shown in other findings from this research, was involved in narratives of 65% of the participants. The contexts of exams, studying, and limits on time were often connected with two of the stress exposure constraints [A] authoritative [B] biological. Seventy-five percent of participants stated that both authoritative and biological constraints were part of their experiences at some point during monitoring. Other notable factors in socio-environmental contexts are classroom/lab settings and academic other (meeting with faculty and advisors, clubs, organizations, and activities connected to the university). Academic settings involving aspects of coursework and extra-curricular activities were mentioned as sources of stress for 45 percent of students. Physical activity was an important part of 90% of participant's daily path, mostly in the form of walking to and from class. Additionally, social settings and personal relationship interactions were generally a source of relaxation and identified in participant survey responses as integral to coping with daily stressors.

### *Place Influences on Stress*

The participant survey (Appendix E) provides information about places on the Texas A&M University campus that students taking part in this research associate with stress.

Texas A&M students perceive diverse places as contributing to their stress levels but the underlying connections between these places are largely authority (A) situations or coupling (C) situations. Many of the stressful places cited by students are related to courses that they are taking, their jobs, contact with the Corp of Cadets, or social interactions that they are uncomfortable with.

The references to stressful places associated with academic courses were more numerous than those having to do with jobs or social interactions. For example students said, *"Heldenfels building because almost all my classes are in there," "The chem. Lab building because I hate chemistry and the tests are hard," "Well, if I have a test for a certain class I get stressed in that location by my class,"* and *"I feel stressed in my professors' offices."* Dealing with exam, difficult class, and subjects or authority figures that they do not like seems to cause students to perceive a place as stressful. The students have no qualms about expressing what they do not care for within the academic setting. *"Bio lab, I don't like bio lab that much, plus the TA (teaching assistant) likes to pick on people,"* and *"…the sociology building (Jack E. Brown Chemical Engineering Building) because I absolutely despise sociology!"*

Only a few of the students participating in this research held jobs. Some students with jobs on campus mentioned their work sites as stressful places. The reasons behind their stress perceptions were disparate, *"Yes, my office the Corps Recruiting Center. It can get very busy and a lot can be asked of me,"* and *"The Natatorium in the Rec Center because that's where I work and when I go to work I'd usually rather be doing something else."*

Certain kinds of social interactions or anticipation of interactions are a factor in student's perceptions of stressful places. *"I think my bedroom/dorm makes me feel stressed, maybe because my roommate is there, and also the cafeteria at the Commons…," and "Also in dark alleys or when I'm at the store at night."* It is unclear exactly what the students are anticipating in these places but it is obvious that their expectations are not positive. Other students provided more clarity about the negative aspects of social interactions certain places. *"Sbisa makes me uncomfortable because there are so many people. Southside makes me stressed because of the Corps' yelling and the formal atmosphere created by Corp members sometimes."* From the perspective of a Corp Cadet certain places on campus feel like being in a fishbowl, *"The Quad and my dorm because I have to be careful about what I say, wear, do, and where I go."*

When it comes to temporal/locational patterns in student stress, although this study examines only three days (sessions) in a person's life, there are both individual and more generalized patterns. Generally speaking, when one of the participants encountered a stressor, such as being late for class, that event influenced his or her reaction to what immediately followed, as evidenced by audio entries. A previous or ongoing stressor seemed to make the activities that followed like waiting for the bus, waiting for an elevator, a quiz or exam in class more likely to be appraised as stressful as well. Also due to the spatial nature of some of the data, patterns can be seen in a person's path where routines like being late for class or disliking a particular class were expressed as recurring HRR episodes. Another type of pattern was the anticipatory pattern, in which the individual knew that an event, already deemed as stressful, was coming up and so the

individual had HRR events leading up to and through that experience. For example this participant's response to identifying stressful places on campus was, *"Dorm room when I'm late for something or worried about something, also in my classes when I have an assignment or test to accomplish."* Coding analysis also revealed anticipation of stressful events as one of the "causes of" stress exposure.

**Self-Reported Versus Mobile Monitoring**

Does a field tracking (GPS/HR monitoring) method expressed in mapped HRR events differ from participants' audio diary accounts? As expected, there are differences between the GPS/HR-monitored data and the self-reported audio data. The monitored data are time and space specific but there are gaps in the data because of user error and GPS unit limitations. In comparison, the audio data were not continuous, and entries were recorded only when the participant consciously experienced stressful situations, recorded locations, reported activities, or related other information. Because the audio diaries were completely subjective, some participants provided a lot of information while others were brief. Related to participant discernment of what to include in the audio entries, some participants were very detailed regarding time, place, constraint, explanatory information, and reflections, while others did not include much detailed information.

The GPS/HR data did match many of the participant-reported HRR events but not all (see Tables 8-27). There were times when students reported what they believed was a stressful event but there was no corresponding HRR episode. Also, many of the

participants failed to report periods of physical activity such as walking to class, but mapping of the spatial data revealed the difference between stationary and mobile occurrences via point patterns. One of the most telling differences between the two types of data is when it is prospective versus retrospective. When the diary entries were retrospective they often lacked temporal or geographic specifics. In some instances, with other collected information such as building names or time ranges, the entries could be matched to the tracked data. Unfortunately, in other cases because of the effects of recall bias (Berney and Blane 1997; Van Den Brink, Bandell-Hoekstra, and Abu-Saad 2001), omissions, chronological inaccuracies, lack of detail, and so forth, the entry information could not be associated to the logged data.

### *Correlation Coefficient Statistics*

Using mobile measurement protocols fostered a high level of concordance between self-reported and equipment monitored data. These concordance levels are tempered by the fact that there is missing data assumed to be a consequence of both user error and equipment limitations. Seventy-five percent of the participants with heart rate (HR) logs displayed a high level of concordance between students reporting stressful experiences and the monitoring equipment logging elevated beats per minute (see Table 28). Sixty-five percent of the participants with GPS data logged GPS entries that temporally corresponded with the time spans reported in audio entries. Those with sufficient GPS logs showed a perfect correlation coefficient (1.000) between self-reported audio accounts and GPS locations during stress exposures.

The majority of category (1) HRR episodes are tailed. Out of 103 total events 80 are tailed and 23 are discrete. For discrete HRR occurrences cluster in the lower time ranges; twenty-one of the twenty-three are 5 minutes or less in duration. In contrast, tailed HRR events are fairly evenly distributed among the 6 time periods ranging from under 1 minute to more than 30 minutes. Statistical analysis of discrete HRR events returned a high correlation coefficient of 0.802 and tailed HRR events returned a correlation coefficient of 0.983. The coefficients are statistically significant at 0.01, the 99 percent confidence interval. Both types of HRR are part of stress exposure; therefore it makes sense that they would display at least a mid-level association to each other.

## Additional Findings

### *Privacy*

In light of society-wide discussions of privacy and an increasing concern regarding its lack in this technological age, it is surprising, but on the other hand perhaps inevitable that today's university undergraduates are relatively unconcerned about the issue. As Weaver and Gahegan (2007) state, surveillance is rapidly becoming commonplace, just another utility and locationally aware technologies are ubiquitous (Sui 2005), embedded in most new technological devices. In many spheres of daily life from credit card purchases, to social networking sites (MySpace, Facebook, Twitter, etc.), to GPS in cell phones, to high-resolution satellite imagery, people have already given up their privacy both willingly and unwillingly. Credit card companies sell purchasing information, stores track customer purchases with rewards cards, stop lights track red light runners,

EZ passes record identity/time on toll roads, library cards track member reading materials, home addresses can be obtained from the internet, and so on. Basically, as Weaver and Gahegan (2007) put it "...people's reasonable expectation of privacy is diminishing" (Weaver and Gahegan 2007, 327), an argument can be made that it is already gone.

In response to a question about privacy concerns on the participant survey given during training, only one student expressed any concern about privacy. The lack of concern could be due in part to the fact that the research had already been approved by the Institutional Review Board and they had the assurance that their personal data would not be linked with their identities. The other perspective as previously discussed is that these were students born in the late 1980s and early 1990s and have become accustomed to a high level of technological presence from a young age and regularly partake in social media such as Facebook, cell phones, navigation systems, and other locationally aware technologies, both explicitly and implicitly, which relegate privacy to a lesser priority than utility. Benefits directly conferred when individuals are using LBS (location-based services) appear to ameliorate the need or concern for privacy (Weaver and Gahegan 2007). Below is a list of the participant responses on the issue of privacy in regard to being monitored for this project.

### *Perceptions of Monitoring*

The participants of this study did not seem to mind being part of a research project that required monitoring of their locations and heart rate for extended periods of time.

Their responses on the participant information survey can be divided into two different categories; (1) completely positive: excited or interested in being monitored and (2) accepting: expressing some concern. They echo the increasing comfort and lack of concern of modern society with regard to various forms of monitoring.

Responses from participants who were completely positive about the experience include, *"I feel fine, I am actually very interested in seeing how it's going to turn out"* (participant 201), *"It's cool! I've had to wear heart rate monitors for training in soccer, so I'm kind of used to them"* (participant 202), *"I don't mind being tracked because I really don't think it's invading my privacy or anything"* (participant 216), and *"I think it's interesting! A new experience for me!"* (participant 206). Some of participants were accepting but expressed some apprehensions or qualifiers to being monitored. One of the participants said, *"As long as my individual information isn't given out with my name on it, that is my only concern"* (participant 223). Another member confides, *"I am a little nervous but I know I can't mess up"* (participant 207). A concern for one contributor was more focused on the knowledge of being monitored and how it might affect her, *"I might feel a little self-conscious but it will not affect my daily routine"* (participant 212).

For the majority of the participants the sentiments *"I think it's cool"* (participant 208) or *"It doesn't bother me"* (participant 210) best represent how they feel about GPS/HR monitoring. Those participating that did have concerns simply do not want their personal information to be available to others. Although, no one commented on it the information recorded in the self-report audio diaries is more intimate in nature.

***Student Definitions of Stress***

During the training session the participants completed the participant survey, which collected demographic data, health background related to confounding factors, attitudes toward privacy, definitions of stress, coping strategies, and other pertinent data. Two of the survey questions elicited their views on stress and revealed that they already had particular notions on what stress is and what is stressful to them as individuals. Both of these notions played into what individuals chose to report in their entries; we are socialized to believe that some situations will be stressful whether we actually experience them that way or not.

During the training sessions prior to the field monitoring periods the participants provided definitions of stress as part of the participant survey. The majority of the definitions were similar, expressing their understanding of stress, as it pertains to this study, as a negative mental state caused by situations that are perceived as difficult. Some of the most comprehensive definitions include, *"Mental or physical pressure from anything in life. Generally worries, fears, or anxiety about situations or events," "Being worried about something, thinking something is too much to handle," "Something connected between mind and body that at healthy levels can help you perform at your best but at high, unhealthy levels can impede your day to day life,"* and *"Stress is pressure, time constraints, or having to do things that you are not comfortable doing."* The participants also revealed some of the sources of stress in their daily lives through the definitions; *"Stress is when I feel overwhelmed with a lot of schoolwork, mainly*

*exams,"* and *"Stress is pressures from work, sports, school, peers, society, yourself to 'perform' a certain way in a limited amount of time."*

***Daily Experiences of Stress***

The collected data reveals that each of the students experienced stress during some portion of their monitoring period. However, there were five participants who do not generally consider themselves to be stressed. On the participant survey they responded no to the question about being stressed. Their explanatory responses include, *"No. I usually try to do things that need to be done. If I procrastinate, I take it like a man and do what needs to be done, or face the consequences"* (participant 204), *"Overall no, but currently yes, because I'm graduating and trying to get ready for grad school"* (participant 223), *"Not really. Of course there are stressful times throughout the week (late for work/class, tests, homework, relationships) but I wouldn't consider myself stressed"* (participant 221), *"No. I have a ton to do, but I consider myself able to handle it. I would say I'm busy. Stressed is like busy, but to a point when you have trouble handling it"* (participant 214), and *"Only around test days. I stress about whether or not I know the test material"* (participant 222). The five students who do not consider themselves stressed are all male.

Only seven out of the twenty-three students contributing to this research were male. Twice as many females were monitored and due to the overall small sample size and markedly less male participation no analysis was performed focusing on gender differences. The survey responses do suggest a difference in gender assessment of

personal stress. Two of the male participants discussed their lack of stress in terms of, *"If I procrastinate, I take it like a man and do what needs to be done, or face the consequences,"* and *"…I consider myself able to handle it."*

Most of the students said that their stressful experiences are related to school pressures, having a lot to do academically or otherwise, or dealing with family. A common theme associated with experiencing stress is time pressure associated with academics. *"I feel very stressed because I feel as though I have a lot to do in a short amount of time…"* (participant 216), *"Yes, when tests come around or I have too much school work to do in one week…* (participant 217), *"I constantly have homework to do or tests to study for. I don't get a break from school that often"* (participant 202) and "*Yes. I am way too busy with school, work, activities, friends, etc."* (participant 203). It seems that constantly having something to do or having limited times to complete tasks is a source of stress.

For some students family issues and demands from other entities exert pressure on top of academic obligations. "Yes*, going through a lot with family, maintaining grades while working, overcommitted in organizations"* (participant 220), *"… I do consider myself stressed when I talk with my mother on a certain issue"* (participant 218), *"Yes. Pressures from my family situation, as well as the pressure I put on myself to maintain my GPA causes great stress in my life"* (participant 208), and *"Yes, the Corps is constantly demanding so much while trying to get a degree, it can be very overwhelming"* (participant 210). Social support can often help people deal with life stress but sometimes social connections are a burden (Glanz, Rimer, and Lewis 2002).

***Coping Strategies***

Much of the literature on student stress and coping, as previously discussed, focuses on detrimental or maladaptive coping strategies, such as alcohol use, drug use, and binge eating (Naquin and Gilbert 1996; Park, Armeli, and Tennen, 2000; Wolff, Crosby, Roberts, and Wittrock 2000; Park and Levenson 2002; Geisner, Larimer, and Neighbors, 2004). In this research sample, although the data is self-reported, the students believe (fifteen out of twenty-three) that they have good (adaptive) coping skills. In response to the participant survey, when asked to describe their coping strategies for dealing with stress, three out twenty-three mentioned eating as one of their coping strategies but none reported using alcohol or drugs.

The participants' characterizations of their coping strategies fit well into the categories of maladaptive or adaptive. Some of the detrimental coping skill responses include, *"…and sometimes I smoke"* (participant 203), *"I eat a lot and become lazy, often watching lots of TV…"* (participant 208), *"…sometimes I eat…"* (participant 201), and *"Eat"* (participant 204). The majority of the participants relate adaptive coping skills for dealing with the stress in their lives. A few of the more active strategies include, *"Work at the Human Society (play with animals, play soccer (a very good method!)…"* (participant 201), *"Breathe deeply, relax, workout"* (participant 217), *"I've tried yoga but don't have time now"* (participant 210), *"I am on the cycle team…"* (participant 214), and *"Work out, take my dog for a walk…"* (participant 209). Predominately, adaptive coping strategies professed by participants have a social support component (Glanz, Rimer, and Lewis 2002). Family and friends tend to play a large part

in supporting students through difficulties; *"I listen to music, take long showers, pray, vent to a friend, etc."* (participant 206), *"...call my mom, watch TV with my roommate and boyfriend"* (participant 209), *"I try to listen to music, enjoy myself with friends at meals or at club meetings"* (participant 211), *"I try to stay calm. I'll talk with a friend or family member to calm my nerves"* (participant 222), and *"I hang out with friends, but more often play video games or do some other pastime"* (participant 223).

**Summary**

The mobile time geography approach was demonstrated to be feasible. Looking at the matrices (see Tables 8-27) they show that GPS/HR and self-reported stress exposure accounts are gathered for each participant. The majority of entries were given a constraint by the participant or provided enough information for a constraint to be applied to the stressor. Mobile methods successfully distinguished psychological stress exposure in a student population. Some instances of physical activity clearly went unreported based upon movement discerned from mapping. Participants 202, 204, 206, 207, 209, 211, 212, 213, 215, 216, 217, 218, 219, 220, 221, 222, and 223 (see Tables 8-27) provided information that made it possible to distinguish between physical and psychologically based HRR for GPS/HR monitored data corresponding to audio entries. There is a high correlation between the mobile time geography measures and self-reported stress occurrences. Statistical analysis produced correlation coefficients of 1.000 for audio/HRR for 75 percent of participants (see Table 28), and audio/GPS correlations of 1.000 for 100 percent of participants.

Interpretation of place and the influence of time are inherent factors in stress experiences. From the participant survey and recorded narratives places mostly associated with academic courses, work, or uncomfortable social situations were identified as stressors. Results from the matrix (see Table 7) used to summarize the representative narratives support the observation that the most discussed stressors are directly related to academic pursuits. Time pressures affected 65 percent of participants, and stressors associated with exams and studying were related to stress in 85 percent and 60 percent respectively. The coding results marked perceived time scarcity and being late for obligations as two of the "is cause of" relational links to stress exposure (Figure 9). Referring to student narratives several expressed time pressure as a source of stress. For example, participant 201 said, *"So I was like running around and just really stressed out trying to finish everything and um get everything done within in a certain amount of time. So I was really trying to get everything done in time. So I really got myself stressed out."* Participant 204 stated, *"Today I'll probably feel stressed more stressed today out of all of the two other days because I have a lot going on a lot going on."*

An unexpected finding is that stress is often expressed in either discrete or tailed (building and ebbing over time) heart rate reactivity. The HR logs of sixteen of the participants displayed tailed and discrete HRR episodes. It seems a key difference in the manifestation of the two HRR types in this population is that discrete episodes cluster in lengths from 1 second to 5 minutes while tailed event occurrences are spread evenly from 1 second to more than 30 minutes (see Table 4 and Table 5).

# CHAPTER VI

# CONCLUSIONS

Human health effects can be viewed from diverse place and socio-environmental perspectives; our conception of self includes identity and well-being, which is related to our emotional and physiological response to places (Curtis 2010). Additionally, in this study the position of space and place in sociopolitical processes and relations between dominant and subordinate social groups (Curtis 2010; Rainham et al. 2010) can be glimpsed in the participant audio entries associating stressors with constraints (authoritative, biological, and coupling) and spatiotemporal context. Human disease ecology (Figure 117) conceptualizes dynamic interactions between socio-environmental processes, human biology, and human behaviors (Curtis 2010), and the same transactions are at work regarding the role of stress in health (Figure 118). Researchers have already linked both epidemiological and ecological processes influencing physical and biochemical conditions in the environment to human health (Gatrell and Elliot 2009; Curtis 2010; Meade and Emch 2010). The truth reflected in the conceptions connecting human health to the socio-environment come to fruition in the idea that geographical environments comprise material, social, and symbolic dimensions, which merge in particular ways for every individual as they move along their life course trajectory, or on a smaller scale their daily path through time and space (Curtis 2010; Rainham et al. 2010). A more comprehensive understanding of place effects, health-related behaviors, and health-influencing factors requires information on the socio-environmental

processes associated with life contexts (Rainham et al. 2010). Researching stress exposures in this student population from a daily path vantage examines a very individualized human process in the optimal setting and at the appropriate resolution level.

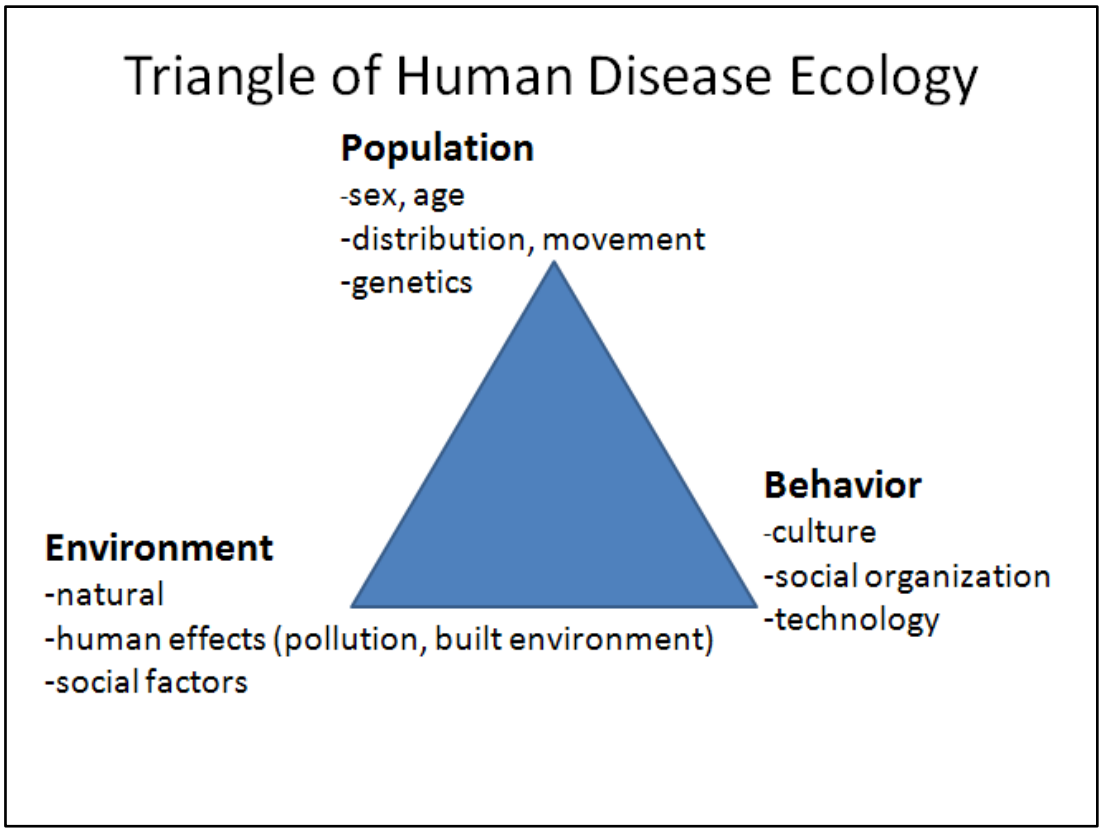



**Figure 117.** Triangle of human disease ecology (Meade and Earickson 2005; Meade and Emch 2010; Gatrell and Elliot 2009). This model is widely accepted and utilized in the public health literature.

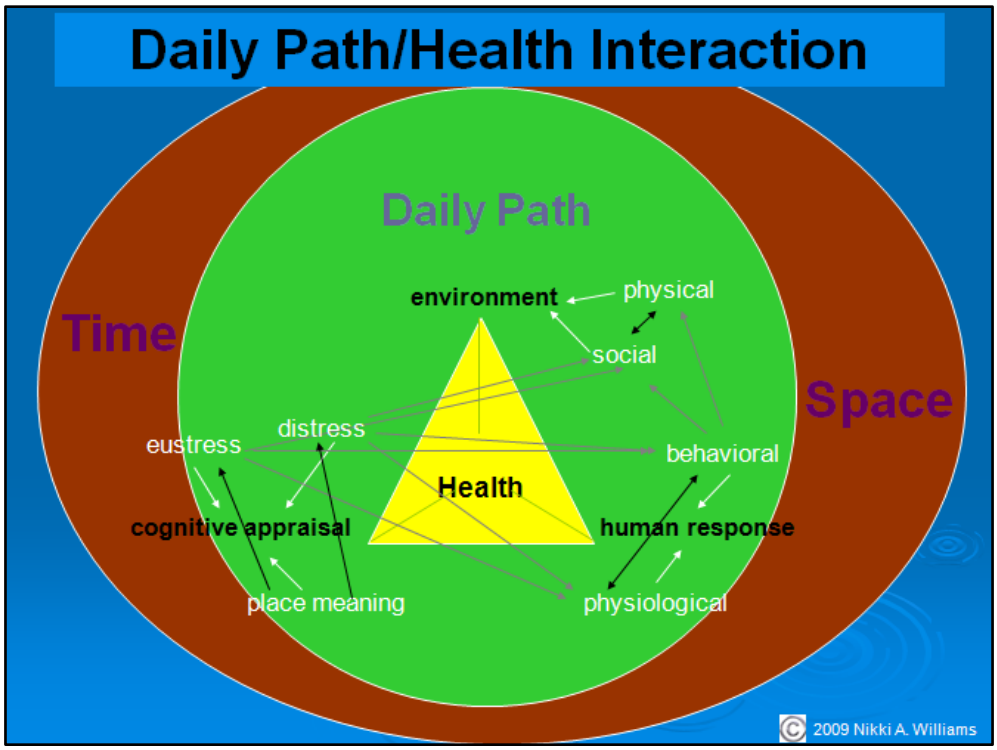



**Figure 118.** Daily path perspective on health and the stress process.

**Demonstrated Utility**

The time geography approach incorporating mobile measures was proven able to identify stress exposures in this sample population and the Hagerstrandian constraints appropriately categorize the various sources of student stressors. It is clear from the results of this proof of concept research that commercial GPS units with synched biomonitors are not only capable of recording elevated heart rate episodes related to psychological stress but additionally are sensitive enough to record events that correspond to participant's reported stress exposures. Sensitivity, that is, accuracy of discerning psychological stress from physical activity, stimulants, or elevations in heart rate due to excitement, was one of the central challenges (feasibility issues) of this

research. 3D mapping of student HRR trajectories allowed for distinguishing when a participant's heart rate elevation was caused by transit (walking, running, biking, etc.) by displaying the GPS points placed farther apart, as a path leading from one location and time to another. Given what can be recorded objectively and subjectively, the data show that participants are not always aware of their personal stress. There are HRR episodes recorded by the GPS/HR units when participants did not make corresponding audio diary entries. These episodes lend additional support to the importance of implicit cognition (Waters and Sayette 2006) in the human appraisal process. The participants of this study were not always aware of their stressful experiences, or possibly did not have time to acknowledge them, or did not choose to share some of them.

Most of the students who attended the focus group admitted to keeping tabs on their heart rate during their monitoring sessions. They noticed that their heart rates were higher when they were stressed. The participants all agreed that the research protocols were easy to follow, that the equipment was easy to use, and that being monitored did not interfere with their daily lives. The main drawback for the participants and the data produced had to do with equipment idiosyncrasies related to the HR sensor strap. Equipment sensor issues could be an error factor in the HRR concordance results.

**Cognitive Appraisal and Socio-environmental Influences on Stress**

One of the primary assertions that can be made about socio-environmental influences on stress, based on this sample, is that places and social situations can be the impetus for stress but individual interpretation through cognition is the process moderator. The

temporal/locational patterns associated with stressors are not so clearly positions on the ground as they are connections made in the landscape of the mind. Stress experiences as much as any other phenomenon happen at a time and in a place. They are inherently geographic because our minds tend to make associations and cognitive appraisal often transforms mere locations into the place where I have that difficult Science class, the place where my lab TA picks on me, the time when the cafeteria is so crowded that I feel overwhelmed, the place where fellow Corp cadets are and I have to watch what I say. A fallacy would be to conceive of stress as arising from mental processes separate from physiological responses and external experiences; this research reveals that stress is often derived from the association of variables from multiple planes such as the mind, body and socio-environmental factors (Curtis 2010; Rainham et al.2010).

Focus groups are a useful strategy for understanding and incorporating participant reflections after data collection is completed (Brown and Lloyd 2001). Recorded focus group sessions were conducted during the spring semester of 2010 to provide reflective information from participants regarding their experiences with this research. In general they stated that places and situations were the foremost factors in their stress exposures. For example, one woman stated that she had to take all of her exams in the testing center (Cain Hall) and that the act of walking into that building made her nervous and her hands got sweaty. She had occasion to be in that building for reasons other than taking exams and found that she had the same type of reactions. A similar connection between place and stress was given by a male participant. He had Computer Science and Linear Algebra classes in Blocker and found that upon entering that building even for reasons

unrelated to class he felt his tension level rising. Additionally, another female participant said she noticed feeling stressed when entering the building that she had her science classes in. She finds her science classes particularly difficult.

Three of the participants spoke about another type of association of place and stress. Sometimes it is not the place itself but the current characteristics of the place that contribute to a person's stress level. One woman noted that the classrooms that had a lot of people densely packed together elicited an anxiety response in her. Another participant spoke of places where people converged and the overwhelming aspect of congestion and that this often happens at times such as the end of the day or when people are changing classes. A woman who lives on campus noticed that the destination did not matter but any time she was away from the campus she felt more relaxed.

**Concordance**

Both HRR and GPS concordance with audio diary accounts given by participants was quite high. The GPS concordance was 100 percent and the HRR concordance was 75 percent. The results in the small sample bode well for employing such measures on larger scale groups. Difference in HRR and GPS concordance are a result of reported stress exposure not being reflected in the HR logs as well as students' not always being aware of or reporting when they are experiencing stress. When investigating a health related issue like stress the participants demonstrate a high level of interest because of what it could reveal about the influence of stress in their lives. Their interest level likely had a strong impact on their follow through and adherence to protocol.

The lack of correlation between the SSI psychometric and the ambulatory measure of HRR might be due to fact that the geographic perspective appears to expand the current parameters of stress exposure assessment. Mobile bio-monitoring gives an automatic and therefore objective valuation of events as opposed to a static measurement. The objective field monitoring is contextualized and augmented by the associated stress exposure narratives. Utilizing spatiotemporal measures to discern and discuss stressors as an integrated part of participants' daily paths provides deeper insight into perceptions linked to physiological responses.

**Important Implications**

In the literature on stress there are terms discussed such as "chronic stress" (Davidson and Baum 1986; Dallman et al. 2003) and "discrete life events" (Holmes and Rahe 1967) but there is nothing found that seems to discuss heart rate or heart rate reactivity episodes in terms of being discrete or tailed in nature. Among the logged HRR events some start and end abruptly while others build up and/or taper off at the end. Both "discrete" and "tailed" HRR occurrences were present in the collected data. According to the data stress exposures are more often expressed as tailed HRR events than discrete HRR. These episodes do not reveal the difference between psychological and physical stress exposures. It is unexplained as to why some events show discrete HRR and others show tailed. This variation in HR expression needs to be investigated further.

Monitoring and assessing individual stress, which is still often done through retrospective means, can be done prospectively in the field with relative accuracy. The

field method captures the instances as they occur, not hypothesized or filtered through a value system regarding what should and should not cause stress. GPS/HR data was collected in real time and 83 percent of the audio diary entries were also made prospectively. In health studies, time geography methods reveal powerful insights and explanatory details, especially when combined with physiological metrics, personal narratives, and additional contextual information (Rainham et al. 2010). Similar methods could be used, with some alteration, to study other cognitive issues that relate to health.

**Future Research**

Inevitably, research results often generate new questions about the subject under investigation. Some questions that arose in this study focus on patterns of stress responses and how stressful experiences are perceived with the passage of time. Are general stress patterns different in relation to the socio-environment based on a person's gender identification, ethnicity origin, ethnic identification, or level of self-efficacy (self-confidence)? Addressing this question would require a larger and more diverse study sample as well as a psychometric to assess personal self-efficacy levels. Robotham (2008) suggests that students stress research needs larger samples, a broader inclusion of majors, and longitudinal approaches to assess how stress experiences (and coping) might change over time or as participants mature.

Dealing with student samples on a larger scale should include stratification protocols for ethnic background, gender identity, sex, socioeconomic level of parents, employment status, history of abuse, known coping strategies, and other possible variables that are

known to affect situation perceptions or possible health outcomes of stress. Technological developments in the form of other ambulatory biometrics such as heart rate variability (HRV), blood pressure (BP), cortisol level, skin conductance, and temperature would provide more precise objective resolution on the physiological expression of stressors (Fried 1984; Sharpley 2002). Additionally, new generation LATs and personal recording devices are becoming less obtrusive and could possibly improve the quality of observational data.

In this study, innovative research methods were used to investigate how cognitive appraisal, place meaning, and socio-environmental influences relate to stress exposures in college students. This initial proof of concept research needs to be applied not only on a larger scale but also one consisting of more diversity to be generalizable in the realm of cognitive related health issues. Discrete versus tailed HRR occurrences are the most interesting finding from this research and expanding on this insight requires investigation into the factors that produce the difference in HR expression. The collected data does not provide additional discernment because the logged HRR episodes are a mixture of tailed and discrete without an evident pattern. For example, a participant might have several HRR occurrences; some of their tailed events are due to psychological distress and others are related to physical activities.

At least half of the participants with documented category (1) HRR events logged both tailed and discrete characteristics. Overall more tailed HRR events, 78 percent, were logged than discrete. Pearson's *r* showed that both discrete and tailed HRR had a high correlation with HRR category (1) occurrences. As stated previously this reflects

the fact that both types of HRR are associated with student stress exposures and that the tailed expressions of HR happen more frequently. Extending the duration of monitoring sessions in addition to the expansion of sample size should allow parametric statistics like multiple regression to predict  for a given participant or a general sample to what degree HRR events are likely to be tailed or discrete (Urdan 2005) for physical and psychological stress exposures.

Another avenue of inquiry produced by this research is the crux of the difference between mobile and static measures. What was the cause of the SSI values and HRR event counts not having an evident correlation? Why did the static and the mobile stress measures not show a more significant alignment? Is the perception of stress experiences different when assessed prior to or after occurrences versus when they are happening? This research demonstrated that the mobility of the field method, which encourages the participant to report stressors as they occur, facilitates a more precise understanding of contributing factors in stressful experiences. Improvements in precision can only be determined through reproduction and expansion of research using active measurement.

Regarding investigations of other types of exposures or target populations, work needs to be done in the areas of Post-Traumatic Stress Disorder (PTSD) impetuses in combat and refugee communities (Gatrell and Elliot 2009). Elderly populations could benefit from tracking studies of patients with Alzheimer's disease and dementia that could provide insight into particular hazards' risk and the rate and nature of cognitive deterioration based on the coherence of personal accounts and data from unobtrusive observational equipment (Shoval et al. 2008). Finally, because of the increased reported

incidence and media profile of autism, understanding the personal landscapes of people with Aspberger's syndrome or other lesser functioning forms of autism could improve understanding and communication.

# REFERENCES

Abouserie, R. 1994. Sources and levels of stress in relation to locus of control and self-esteem in university students. *Educational Psychology* 14 (3): 323-30.

American College Health Association. 2009. *Stress in college: What everyone should know.* Baltimore, MD: American College Health Association.

Anderson, B., and M. Pulich. 2001. Managing workplace stress in a dynamic environment. *The Healthcare Manager* 19 (3): 1-10.

Andrews, B., and J. M. Wilding. 2004. The relation of depression and anxiety to life-stress and achievements in students. *British Journal of Psychology* 95: 509-21.

Arsand, E., R. Varmedal, and G. Hartvigsen. 2007. Usability of a mobile self-help tool for people with diabetes: The easy health diary. *Proceedings of the 3rd Annual IEEE Conference on Automation Science and Engineering,* 863-68. Scottsdale, AZ.

AvRuskin, G. A., G. M. Jacquez, J. R. Meliker, M. J. Slotnick, A. M. Kaufmann, and J. O. Nriagu. 2004. Visualization and exploratory analysis of epidemiologic data using a novel space time information system. *International Journal of Health Geographics* 3 (26): 1-10.

Bailey, D. M. 1997. *Research for the health professional: A practical guide*, 2nd ed. Philadelphia, PA: F. A. Davis Company.

Balogun, J., and G. Johnson. 1998. Bridging the gap between intended and unintended change: The role of managerial sensemaking. In *New managerial mindsets: organizational transformation and strategy implementation,* eds. M. A. Hitt, J. E. Ricart I Costa, and R. D. Nixon, 55-82. New York, NY: John Wiley.

Balogun, J., A. S. Huff, and P. Johnson. 2003. Three responses to the methodological challenges of studying strategising. *Journal of Management Studies* 40: 197–224.

Bernard, P., Charafeddine, R., Frohlich, K. L., Daniel, M., Kestens, Y., & Potvin, L. 2007. Health inequalities and place: a theoretical conception of neighbourhood. *Social Science & Medicine 65*: 1839–52.

Berney, L. R., and D. B. Blane. 1997. Collecting retrospective data: Accuracy or recall after 50 years judged against historical records. *Social Science and Medicine* 45 (10): 1519–25.

Bottero, W., and K. Prandy. 2003. Social interaction distance and stratification. *British Journal of Sociology* 54: 177–97.

Boyle, M. H., and J. D. Willms. 1999. Place effects for areas defined by administrative boundaries. *American Journal of Epidemiology* 149 (6): 577–85.

Boys, J. 1990. Beyond maps and metaphors? Re-thinking the relationships between architecture and gender. In *New frontiers of space, bodies, and gender,* ed. F. Ainley, 203-17. New York, NY: Routledge.

Bressert, S. 2006. *Stress management basics.* http://psychcentral.com/lib/2006/stress-management-basics/ (last accessed 30 Oct 2007).

Brown, C., and K. Lloyd. 2001. Qualitative methods in psychiatric research. *Advances in Psychiatric Treatment* 7: 350–56.

Brown, M., and S. Ralph. 1999. Using the DYSA programme to reduce stress and anxiety in first-year university students. *Pastoral Care* 17 (3): 8-13.

Buchanan, D., and D. Boddy. 1992. *The expertise of the change agent: Public performance and backstage activity.* Englewood Cliffs, NJ: Prentice-Hall.

Burgess, R. G. 1984. *In the field: An introduction to field research.* London, UK: George Allen and Unwin.

Bush, H. S., M. Thompson, and N. Van Tuvergen. 1985. Personal assessment of stress factors for college students. *Journal of School Health* 55 (9): 370-75.

Carvalho, C., and B. M. Gadzella. 2006. Locus of control: Differences among college students' stress levels. Paper presented at the *4th Annual Pathways Research Symposium*. Prairie View, TX: Prairie View A&M University.

Cohen, S., D. Janicki-Deverts, and G. E. Miller. 2007. Psychological stress and disease. *JAMA* 298 (14): 1685–87.

Cohen, S., R. C. Kessler, and L. U. Gordon. 1997. *Measuring stress: A guide for health and social scientists*. New York, NY: Oxford University Press.

Cohen, S., and G. M. Williamson. 1991. Stress and infectious disease in humans. *Psychological Bulletin* 109 (1): 5–24.

Curtis, S. 2010. *Space, place and mental health*. Surrey, UK: Ashgate Publishing Limited.

Curtis, S., and I. A. Jones. 1998. Is there a place for geography in the analysis of health inequality? *Sociology of Health & Illness* 20: 645–72.

Dallman, M. F., N. Pecoraro, S. F. Akana, S. E. la Fleur, F. Gomez, H. Houshyar, M. E. Bell, S. Bhatnagar, K. D. Laugero, and S. Manalo. Chronic stress and obesity: A new view of "comfort food." *Proceedings of the National Academy of Sciences* 100 (20): 11696-11701.

Davidson, L., and A. Baum. 1986. Chronic stress and posttraumatic stress disorders. *Journal of Consulting and Clinical Psychology* 54 (3): 303-08.

Dear, M. J., and J. R. Wolch. 1987. *Landscapes of despair: From deinstitutionalization to homelessness.* Princeton, NJ: Princeton University Press.

DeLongis, A., J. C. Coyne, G. Dakof, S. Folkman, and R. S. Lazarus. 1982. Relationship of daily hassles, uplifts, and major life events to health status. *Health Psychology* 1 (2): 119–36.

Diez Roux, A. V., L. Chambless, S. S. Merkins, D. Arnett, M. Eigenbrodt, F. J. Nieto, M. Szklo, and P. Sorlie. 2002. Socioeconomic disadvantage and change in blood pressures associated with aging. *Circulation* 106: 703–10.

Dubos, R. 1965. *Man adapting*. New Haven, CT: Yale University Press.

Duncan, J.S., H. M. Badland, and G. J. Schofield. 2008. Combining GPS with heart rate monitoring to measure physical activity in children: A feasibility study. *Journal of Science and Medicine in Sport* 12 (5): 583–85.

Dyck, I. 1990. Space, time and renegotiating motherhood: An exploration of the domestic workplace. *Environment and Planning D: Society and Space* 8: 459–83.

Dyck, I., and P. Dossa. 2007. Place, health, and home: Gender and immigration in the constitution of a healthy space. *Health & Place* 13 (3): 691-701.

Elgethun, K. 2004. *Global positioning system (GPS) tracking to characterize children's exposure to pesticides.* Ph.D. dissertation, The Graduate School, University of Washington. Seattle, WA.

Elgethun, K., R. A. Fenske, M. G. Yost, and G. J. Palcisko. 2003. Time-location analysis for exposure assessment studies of children using a novel global positioning system instrument. *Environmental Health Perspectives* 111 (1): 115–22.

Elgethun, K., M. G. Yost, C. T. E. Fitzpatrick, T. L. Nyerges, and R. A. Fenske. 2007. Comparison of global positioning system (GPS) tracking and parent-report diaries to characterize children's time-location patterns. *Journal of Exposure Science and Environmental Epidemiology* 17: 196-206.

Ellaway, A., S. Macintyre, and A. Kearns. 2001. Perceptions of place and health in socially contrasting neighbourhoods. *Urban Studies* 38 (12): 2299–2316.

Environmental Systems Research Institute (ESRI). ArcGIS: ArcMap 10 software. Redlands, CA.

Epel, E. S., E. H. Blackburn, J. Lin, F. S. Dhabhar, N. E. Adler, J. D. Morrow, and R. M. Cawthon. 2004. Accelerated telomere shortening in response to life stress. *Proceedings of the National Academy of Sciences* 101 (49): 17312–15.

Everly, G. S., and B. Herbert. 1989. Disorders of arousal and the relaxation response: Speculations on the nature and treatment of stress-related diseases. *International Journal of Psychosomatics* 36 (1-4): 15-21.

Everly, G. S. 2002. *A clinical guide to the treatment of the human stress response*. New York, NY: Kluwer Academic/Plenum Publishers.

Fried, Y., K. M. Rowland, and G. R. Ferris. 1984. The physiological measurement of work stress: a critique. *Personal Psychology* 37 (4): 583-615.

Frohlich, K. L., E. Corin, and L. Potvin. 2001. A theoretical proposal for the relationship between context and disease. *Sociology of Health and Illness* 23 (6): 776-97.

Gadzella, B. M. 1991. *Student-life Stress Inventory (SSI)*. Copyrighted metric. Commerce, TX.

Gadzella, B. M. 1994. Student-Life Stress Inventory (SSI): Identification of and reactions to stressors. *Psychological Reports* 74: 395–402.

Gadzella, B. M., and M. Baloglu. 2001. Confirmatory factor analysis and internal consistency of the student-life stress inventory. *Journal of Instructional Psychology* 28 (4): 84–94.

Gadzella, B. M., H. L. Fullwood, and M. Tomcala. 1992. Students' stressors and reactions to stress. Paper presented at the *Southwestern Psychological Association Convention.* Austin, TX.

Gadzella, B. M., W. G. Masten, and J. Stacks. 1998. Students' stress and their learning strategies, test anxiety and attributions. *College Student Journal* 32 (3): 416-23.

Gadzella, B. M., J. R. Stacks, V. K. Thompson, R. C. Stephens, and W. G. Masten. 2004. College students' perceptions and ratings of their stress. Paper presented at the *Southwestern Psychological Association Convention.* San Antonio, TX.

Garmin Ltd. Forerunner 305 wristwatch GPS. Olathe, KS.

Gatrell, A. C., and S. J. Elliott. 2009. *Geographies of health an introduction*, 2nd ed. West Sussex, UK: John Wiley & Sons.

Geisner, I. M., M. E. Larimer, and C. Neighbors. 2004. The relationship among alcohol use, related problems, and symptoms of psychological distress: gender as a moderator in a college sample. *Addictive Behaviors* 29: 843-48.

Glanz, K., B. K. Rimer, and F. M. Lewis. 2002. *Health behavior and health education: Theory, research, and practice, 3rd ed*. San Francisco, CA: Jossey-Bass.

Golledge, R. G., and R. J. Stimson. 1997. *Spatial behavior: A geographic perspective.* New York, NY: The Guilford Press.

Goyne, R. M. 2005. Self-reported data in institutional research: Review and recommendations. *New Directions for Institutional Research* 127: 73–89.

Graham, H. 2000. *Understanding health inequalities.* Buckingham, UK: Open University Press.

Gren, M. 2001. Time-geography matters. In *Timespace: geographies of temporality*, eds. May, J., and N. Thrift, 208–25. London, UK: Routledge.

Gunderson, E. K., and R. H. Rahe. 1974. *Life stress and illness*. Springfield, IL: Charles C. Thomas.

Hagerstrand, T. 1970. What about people in regional science? *Papers of the Regional Science Association* 24 (1): 6–21.

Ham, L. S., and D. A. Hope. 2004. College students and problematic drinking: a review of literature. *Clinical Psychology Review* 23: 719-59.

Harvey, L., S. Drew, and M. Smith. 2006. *The first year experience: A review of literature for the higher education academy*. New York, NY: The Higher Education Academy.

Hedley, N. R., C. H. Drew, E. A. Arfin, and A. Lee. 1999. Hagerstrand revisited: Interactive space-time visualizations of complex data. *Informatica* 23 (2): 155–68.

Hein, J. R., J. Evans, and P. Jones. 2008. Mobile methodologies: Theory, technology and practice. *Geography Compass* 2 (5): 1266–85.

Holmes, T. H., and R. H. Rahe. 1967. The social readjustment rating scale. *Journal of Psychosomatic Research* 11 (2): 213–18.

Holmes, D. S., and D. L. Roth. 1985. Association of aerobic fitness with pulse rate and subjective responses to psychological stress. *Psychophysiology* 22 (5): 525–29.

Hufford, M. R., A. L. Shields, S. Shiffman, P. Jean, and M. Balabanis. 2002. Reactivity to ecological momentary assessment: An example using undergraduate problem drinkers. *Psychology of Addictive Behaviors* 16 (3): 205–11.

Hunter, R. G., K. J. McCarthy, T. A. Milne, D. W. Pfaff, and B. S. McEwen. 2009. Regulation of hippocampal H3 histone methylation by acute and chronic stress. *Proceedings of the National Academy of Sciences* 106 (49): 20912–17.

International Business Machines Corp. (IBM). SPSS: PASW Statistics 18 software. Armonk, NY.

Jerrett, M., and M. Finkelstein. 2005. Geographies of risk in studies linking chronic air pollution exposure to health outcomes. *Journal of Toxicology and Environmental Health* 68A: 1207–42.

Johnson, C., and C. Bowman. 1999. Strategy and everyday reality: The case for the study of micro-strategy. Paper presented at the 15th *EGOS Conference.* Warwick, UK.

Johnston, R. J., D. Gregory, G. Pratt, and M. Watts. 2000. *The dictionary of human geography*, 4th ed. Malden, MA: Blackwell Publishing.

Jorna, P. 1991. Heart rate variability as an index for pilot workload. *Proceedings of the International Symposium on Aviation Psychology,* 746-51. Columbus, OH.

Jorna, P. G. A. M. 1992. Spectral analysis of heart rate and psychological state: A review of its validity as a workload index. *Biological Psychology* 34: 237-57.

Kanner, A. D., J. C. Coyne, C. Schaefer, and R. S. Lazarus. 1981. Comparison or two modes of stress measurement: Daily hassles and uplifts versus major life events. *Journal of Behavioral Medicine* 4 (1): 1-39.

Kapler, T, R. Harper, and W. Wright. 2005. Correlating events with tracked movements in time and space: A GeoTime case study. Paper demonstrated at the *Intelligence Analysis Conference*. Washington, DC.

Kawachi, I., and L. Berkman. 2003. *Neighborhoods and health.* New York, NY: Oxford University Press.

Kearns, R. A. 1997. Narrative and metaphor in health geographies. *Progress in Human Geography* 21 (2): 269-77.

Kirschbaum, C., K. M. Pirke, D. H. Hellhammer. 1993. The trier social stress test – a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology* 28: 76-81.

Klepeis, N. E., W. C. Nelson, W. R. Ott, J. P. Robinson, A. M. Tsang, P. Switzer, J. V. Behar, S. C. Hern, and W. H. Engelmann. 2001. The national human activity pattern survey (NHAPS): A resource for assessing exposure to environmental pollutants. *Journal of Exposure Analysis and Environmental Epidemiology* 11: 231-52.

Koskela, H., and R. Pain. 2000. Revisiting fear and place: Women's fear of attack and the built environment. *Geoforum* 31 (2): 269–80.

Kwan, M. 1999. Gender and individual access to urban opportunities: A study using space-time measures. *Professional Geographer* 51 (2): 210–27.

Kwan, M., and J. Lee. 2004. Geovisualization of human activity patterns using 3D GIS: A time-geographic approach. In *Spatially integrated social science,* eds. Goodchild, M. F. and D. G. Janelle, 48-66. Oxford, UK: Oxford University Press.

Larsson, P., and K. Henriksson-Larsén. 2001. The use of dGPS and simultaneous metabolic measurements during orienteering. *Medicine and Science in Sports and Exercise* 33 (11): 1919–24.

Lazarus, R. S., J. C. Speisman, and A. M. Mordkoff. 1963. The relationship between automatic indicators of psychological stress: Heart rate and skin conductance. *Psychosomatic Medicine* 25 (1): 19 –30.

Lazarus, R. S. 1984. Puzzles in the study of daily hassles. *Journal of Behavioral Medicine* 7 (4): 375–89.

Lazarus, R. S. 1999. *Stress and emotion: A new synthesis*. New York, NY: Springer Publishing Co.

Lazarus, R. S. and S. Folkman. 1984. *Stress, appraisal and coping*. New York, NY: Springer Publishing Co.

LeCompte, M. D. 2000. Analyzing qualitative data. *Theory into Practice*, 39 (3): 146–54.

Macan, T. H., C. Shahani, R. L. Dipboye, and A. P. Phillips. 1990. College student' time management: Correlations with academic performance and stress. *Journal of Educational Psychology* 82: 760-68.

Macintyre, S., A. Ellaway, and S. Cummins. 2002. Place effects on health: How can we conceptualise, operationalise and measure them? *Social Science & Medicine* 55: 125–39.

Maxwell, J. A. 1998. Designing a qualitative study. In *Handbook of applied social Research Methods,* eds. Bickman, L., and D. J. Rog, 69-100. Thousand Oaks, CA: Sage Publications.

Meade, M. S., and R. J. Earickson. 2000. *Medical geography*, 2nd ed. New York, NY: The Guilford Press.

Meade, M. S., and M. Emch. 2010. *Medical geography*, 3rd ed. New York, NY: The Guilford Press.

Meliker, J. R., M. J. Slotnick, G. A. AvRuskin, A. Kaufmann, G. M. Jacquez, and J. O. Nriagu. 2005. Improving exposure assessment in environmental epidemiology: Application of spatio-temporal visualization tools. *Journal of Geographic Systems* 7 (1): 49–66.

Microsoft Corporation. Excel 2010 spreadsheet software. Redmond, WA.

Milligan, C., A. Bingley, and A. Gatrell. 2005. Digging deep: Using diary techniques to explore the place of health and well-being amongst older people. *Social Science & Medicine*, 61: 1882–92.

Miller H. 2005. What about people in geographic information science? In *Re-Presenting Geographic Information Systems,* eds. Fisher, P., and D. J. Unwin, 215-42. New York, NY: John Wiley & Sons, Ltd.

Miller, H. J. 2007. Place-based versus people-based geographic information science. *Geography Compass* 1: 503–35.

Miller, T. R., T. D. Baird, C. M. Littlefield, G. Kofinas, F. S. Chapin III, and C. L. Redman. 2008. Epistemological pluralism: Reorganizing interdisciplinary research. *Ecology & Society* 13 (2): 46-65.

Misra, R., M. McKean, S. West, and T. Russo. 2000. Academic stress of college students: Comparison of student and faculty perceptions. *College Student Journal* 34 (2): 236-45.

Morgan, G. A., and O. V. Griego. 1998. *Easy use and interpretation of SPSS for windows: Answering research questions with statistics*. London, UK: Psychology Press.

Naquin, M. R., and G. G. Gilbert. 1996. College students' smoking behavior, perceived stress, and coping styles. *Journal of Drug Education* 26 (4): 367–76.

Nonis, S., G. I. Hudson, L. B. Logan, and C. W. Ford. 1998. Influence of perceived control over time on college students' stress and stress-related outcomes. *Research in Higher Education* 39 (5): 587-605.

Oculus. GeoTime 4.0.0 visual analysis of times series data software. Toronto, Canada.

Park, C. L., and M. Levenson. 2002. Drinking to cope among college students: prevalence, problems and coping processes. *Journal of Studies on Alcohol* 63: 486-97.

Park, C. L., S. Armeli, and H. Tennen. 2004. The daily stress and coping process and alcohol use among college students. *Journal of Studies on Alcohol* 65: 126-35.

Perlow, L. A. 1997. *Finding time: How corporations, individuals, and families can benefit from new work practices.* Ithaca, NY: Cornell University Press.

———. 1999. The time famine: Toward a sociology of work time. *Administrative Science Quarterly* 44 (1): 57-81.

Phippen, M. 1995. The 1993/4 survey of counseling services in further and higher education. *Newsletter-Association of Student Counselling* November: 25-36.

Pickett, K. E., and M. Pearl. 2001. Multilevel analyses of neighborhood socioeconomic context and health outcomes: A critical review. *Journal of Epidemiology Community Health* 55: 111–12.

Pollack, M. H. 1991. Heart rate reactivity to laboratory tasks and ambulatory heart rate in daily life. *Psychosomatic Medicine* 53: 1-12.

Popay, J., C. Thomas, G. Williams, S. Bennett, A. Gatrell, and L. Bostock. 2003. A proper place to live: Health inequalities, agency and the normative dimensions of space. *Social Science & Medicine* 57: 55–69.

Pred, A. 1977. The choreography of existence: comments on Hagerstrand's time-geography and its usefulness. *Economic Geography* 53 (2): 207–21.

Rainham, D., I. McDowell, D. Krewski, and M. Sawada. 2010. Conceptualizing the healthscape: Contributions of time geography, location technologies and spatial ecology to place and health research. *Social Science & Medicine* 70: 668–76.

Radio Corporation of America (RCA). VR5220 digital voice recorder. Issy les Moulineaux, France. Technicolor SA.

Reisberg, L. 2000. Student stress is rising, especially among young women. *Chronicle of Higher Education* 46 (21): 49-50.

Robinson, J. P. 1999. *Time for life,* 2nd ed., 57–67. State College, PA: Penn State Press.

Robinson, J. P., and A. Bostrom. 1994. The overestimated workweek? What time diary measures suggest. *Monthly Labor Review* 117: 11-23.

Rose, G. 1993. *Feminism and geography: the limits of geographical knowledge*. Cambridge, UK: Polity.

———. 1997. Situating knowledges: Positionality, reflexivities and other tactics. *Progress in Human Geography* 21 (3): 305-20.

Ross, S. E., B. C. Niebling, and T. M. Heckert. 1999. Sources of stress among students. *College Student Journal* 33 (2): 312-17.

Ross, R. 1986. The pathogenesis of atherosclerosis: An update. *New England Journal of Medicine* 314: 488-500.

Ross, R., and J. A Glomset. 1976a. The pathogenesis of atherosclerosis (1 of 2). *New England Journal of Medicine* 295 (7): 369-77.

———. 1997b. The pathogenesis of atherosclerosis (2 of 2). *New England Journal of Medicine* 295 (8): 420-25.

Robotham, D. 2008. Stress among higher education students: Towards a research agenda. *High Educ* 56: 735-46.

Sack, R. 2003. *A geographical guide to the real and the good*. New York, NY: Routledge (Taylor and Francis Books, Inc.).

Sapolsky, R. M. Individual differences and the stress response. *Seminars in the Neurosciences* 6: 261-69.

Schaerstrom, A. 1996. *Pathogenic paths? a time geographical approach in medical geography*. Lund, Sweden: Lund University Press.

Schaerstrom, A. 1999. Apparent and actual disease landscapes – some reflections on the geographical definition of health and disease. *Geografiska Annaler* 81B (4): 235–42.

Schaerstrom, A. 2005. *Epidemiological landscapes – health and ill health in time and space*. http://www.google.com/search?hl=en&lr=&q=schaerstrom%2Bepidemiological+landscapes (last accessed 14 February 2006).

Schafer, W. 1996. *Stress management for wellness*, 3rd ed. Fort Worth, TX: Harcourt Brace College Publishers.

Scientific Software Development GmbH. ATLAS.ti 5.0 qualitative data analysis and research software. Berlin, Germany.

Selye, H. 1956. *The stress of life,* 1st ed. New York, NY: McGraw-Hill.

———. 1978. *The stress of life,* 2nd ed. New York, NY: McGraw-Hill.

Sharpley, C. F. 1994. Differences in pulse rate and heart rate and effects on the calculation of heart rate reactivity during periods of mental stress. *Journal of Behavioral Medicine* 17 (1): 99-109.

———. 1998. Psychosocial stress-induced heart rate reactivity and atherogenesis: Cause or correlation? *Journal of Behavioral Medicine* 21 (5): 411-32.

———. 2002. Heart rate reactivity and variability as physiological links between stress, anxiety, depression, and cardiovascular disease: Implications for health psychology interventions. *Australian Psychologist* 37 (1): 56-62.

Shiffman, S., and A. A. Stone. 1998. Ecological momentary assessment in health psychology. *Health Psychology* 17 (1): 3–5.

Shiffman, S., A. A. Stone, and M. R. Hufford. 2008. Ecological momentary assessment. *Annual Review of Clinical Psychology* 4 (1): 1-32.

Shoval, N., and M. Isaacson. 2006. Application of tracking technologies to the study of pedestrian spatial behavior. *The Professional Geographer* 58 (2): 172–83.

Shoval, N., G. K. Auslander, T. Freytag, R. Landau, F. Oswald, U. Seidl, H. S. Wahl, S. Werner, and J. Heinik. 2008. The use of advanced tracking technologies for the analysis of mobility in Alzheimer's disease and related cognitive diseases. *BMC Geriatrics* 8 (7): 1-12.

Stanley, N., and J. Manthorpe. 2001. Responding to students' mental health needs: Impermeable systems and diverse users. *Journal of Mental Health* 10 (1): 41-52.

Sui, D. Z. 2005. Will ubicomp make GIS invisible? *Computers, Environment, and Urban Systems* 29 (1): 361-67.

Sunnqvist, C., U. Persson, B. Lenntorp, and L. Traskman-Bendz. 2007. Time geography: A model for psychiatric life charting? *Journal of Psychiatric and Mental Health Nursing* 14: 250–57.

Takahashi, L.M,. D. Wiebe, and Rigoberto Rodriguez. 2001. Navigating the time-space context of HIV and AIDS: Daily routines and access to care. *Social Science & Medicine* 53 (7): 845–63.

Van Den Brink, M., E. N. G. Bandell-Hoekstra, and H. Abu-Saad. 2001. The occurrence of recall bias in pediatric headache: A comparison of questionnaire and diary data. *The Journal of Head and Face Pain* 41 (1): 11-20.

Vrijkotte, T. G. M., L. J. P. van Doornen, and E. J. C. de Gues. 2000. Effects of work stress on ambulatory blood pressure, heart rate, and heart rate variability. *Hypertension* 35: 880-86.

Waters, A. J., and M. A. Sayette. 2006. Implicit cognition and tobacco addiction. In *The handbook of implicit cognition and addiction*, 309-38, eds. Wiers, R.W., and A. W. Stacy. Thousand Oaks, CA: Sage Publications, Inc.

Weaver, S. D., and M. Gahegan. 2007. Constructing, visualizing, and analyzing a digital footprint. *The Geographical Review* 97 (3): 324-50.

Weiner, B., D. Russell, and D. Lerman. 1979. The cognition-emotion process in achievement-related contexts. *Journal of Personality and Social Psychology* 37 (7): 1211-20.

Wetter, D. W., S. K. Welsch, S. S. Smith, M. C. Fiore, S. L. Kenford, R. T. Fouladi, and T. B. Baker. 2004. Prevalence and predictors of transitions in smoking behavior among college students. *Health Psychology* 23 (2): 168-77.

Wolff, G. E., R. D. Ross, J. A. Roberts, and D. A. Wittrock. 2000. Differences in daily stress, mood, coping, and eating behavior in binge eating and nonbinge eating college women. *Addictive Behaviors* 25 (2): 205-16.

Wyckoff, W. B. 2010. *5 Big Health Issues on Campus.* http://www.npr.org/blogs/health/2010/08/31/129562240/top-5-college-health-issues-this-year?sc=emaf (last accessed 4 June 2011).

Zeidner, M., and D. Saklofske. 1996. Adaptive and maladaptive coping. In *Handbook of coping: theory, research, applications,* eds. Zeidner, M., and N. S. Endler, 505-31. New York, NY: John Wiley & Sons.

# APPENDIX A

## PARTICIPANT SOLICITATION

Fellow Texas A & M University Students:

My name is Nikki A. Williams and I am a doctoral student in the Department of Geography. This semester I will be conducting a study for my dissertation research. I am looking for twenty sophomore and junior level students to participate. My study focuses on real-time methods to distinguish student stress exposures as they interact with their environment. Wristwatch GPS units-linked to heart rate monitors, and self-recorded audio accounts are the measurement components. An incentive gift (a digital voice recorder with 512mb memory and USB) will be given to each participant completing the study. A meal will be served at the training and focus group sessions.

You will need to sign a consent form to participate but may withdraw from the study at anytime.

**Participant Requirements:**

- Attend a training/informational session (1-2 hrs)
- During the training session you will be asked to complete the Student-life Stress Inventory, a previously tested and validated stress measure
- During the training session you will be asked to complete the participant survey
- Test period #1 → wear GPS/heart rate monitor to establish baseline heart rate (5hrs...during normal activity) & keep an audio diary of perceptions/activities
- Test period #2 → wear GPS/heart rate monitor for tracking/stress exposure (10hrs...during normal activity) & keep an audio diary of perceptions/activities
- Test period #3 → wear GPS/heart rate monitor for tracking/stress exposure (10hrs...during normal activity) & keep an audio diary of perceptions/activities
- Attend a debriefing focus group session (1-2 hrs)

***Note:** During each test period, participants will be asked to keep an audio diary. The information to include in the audio diary will be covered during the training meeting.

If you are interested in participating in this study, please contact me as soon as possible (nwilliams@geog.tamu.edu).

Thank you.
~Nikki A. Williams

--

Nikki A. Williams
PhD Program
Texas A&M University
Department of Geography
College Station, TX
nwilliams@geog.tamu.edu

# APPENDIX B

## RESEARCH INFORMATION SHEET

### INFORMATION SHEET

Student Stress Exposure: A Daily Path Perspective on the Connections between Time-Locational Sequence, Place, and Stress

**Introduction**

The purpose of this form is to provide you (as a prospective research study participant) information that may affect your decision as to whether or not to participate in this research.

You have been asked to participate in a research study examining how an individual's daily path and perception of places influence their stress responses. The motivation behind this study is threefold. First, I want to gain an understanding of how students' daily chronological/geographical paths and the meanings that they assign to places affect their stress level. Second, the study should yield knowledge regarding how different types of daily interactions like individual capability tasks, tasks that require the involvement of other people, and tasks that are dictated by authority affect students' stress. Finally, discerning the intersections in time/space where individual students are exposed to stressors. Such information can potentially be used in preventive stress management measures directed at improving mental and physical health outcomes.

You were selected to be a participant because you are an undergraduate (sophomore or junior) student at Texas A & M University and this study focuses on college student stress.

**What will I be asked to do?**

If you agree to participate in this study, you will be asked to meet the following requirements...

**Participant Requirements:**

- Attend a training/informational session (1-2 hrs) to learn how to use the GPS/heart rate monitor and personal recording device
- During the training session you will be asked to complete the Student-life Stress Inventory, a previously tested and validated stress measure
- During the training session you will be asked to complete the participant survey
- Test period #1 → wear GPS/heart rate monitor to establish baseline HR (5hrs...during normal activity) and self-record narrative of variables outlined in the audio diary instructions

- Test period #2 → wear GPS/heart rate monitor for tracking/stress exposure (10hrs...during normal activity) and self-record narrative of variables outlined in the audio diary instructions
- Test period #3 → wear GPS/heart rate monitor for tracking/stress exposure (10hrs...during normal activity) and self-record narrative of variables outlined in the audio diary instructions
- Attend a debriefing focus group session (1-2 hrs) to discuss your thoughts and experiences regarding this study

Your participation in the training session and focus group session may be audio recorded.

**What are the risks involved in this study?**
The risks associated with this study are minimal but do include possible emotional discomfort due to recording stressful events (disclosing the situations or places surrounding stressors) and being tracked with a GPS (global positioning system and synchronized heart rate monitor).
In addition, it is possible that participants with sensitive skin might experience discomfort from wearing the wristwatch GPS unit and synched heart rate monitor for several hours at a time. The likelihood of discomfort depends on the individual and cannot be predicted beforehand.

**What are the possible benefits of this study?**
The possible benefits of participation are becoming more aware of the times, locations, and situations encountered in your daily life that cause psychological/emotional stress. Gaining this level of awareness will enable possible alteration of the factors in your life that cause stress and possibly contribute to compromised health if not addressed. In addition, a real-time stress evaluation methodology is an important step in the development of personal tools that can be used to monitor and improve individual health.

**Do I have to participate?**
No. Your participation is entirely voluntary. You may decide not to participate or to withdraw at any time without your current or future relations with Texas A&M University being affected in any way. If you decide to withdraw from the study your data will be erased.

**Will I be compensated?**
If you complete the study requirements, you will be given a digital voice recorder with 512mb memory and USB (worth approximately $40) as compensation. In addition, you will receive a meal during the training session and focus group session.

**Who will know about my participation in this research study?**

This study, including the data collected is confidential. The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report or publication. Research records will be stored securely and only Nikki A. Williams will have access to the records.

If you choose to participate in this study, you will be audio recorded during the training and focus group sessions. Any audio recordings will be stored securely and only Nikki A. Williams will have access to the recordings. Any recordings will be kept for five years and then destroyed.

**Is there anything else I should consider?**
If you are unable to satisfactorily complete the training session and test #1, which establishes your resting (baseline) heart rate, then you will be withdrawn from the study.

**Whom do I contact with questions about the research?**
If you have questions regarding this study, you may contact Nikki A. Williams, phone number: *, email: nwilliams@geog.tamu.edu.

**Whom do I contact about my rights as a research participant?**
The Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University have reviewed this research study. For research-related problems or questions regarding your rights as a research participant, you can contact these offices at (979)458-4067 or irb@tamu.edu.

**Participation**
Please be sure you have read the above information, asked questions and received answers to your satisfaction. If you would like to be in the study, please sign the participation consent form. A comprehensive participant package will be provided.

# APPENDIX C

## MONITORING EQUIPMENT INSTRUCTIONS

### Garmin Forerunner 305 (GPS) Instructions

1. **Charging the GPS unit:**
   - The unit should already be charged
   - The night before each test period plug the charger into an outlet
   - Place the unit on the cradle to charge
   - The screen display will tell you when charging is completed
2. **Turning the unit on:**
   - Push the top button on the left side of the unit (marked with a red power symbol)
   - It may take a few minutes for the unit to locate satellites, be patient
   - If the display screen asks you a question use the navigation (arrow) buttons on the right side to choose the correct answer, then press the bottom right button labeled enter
3. **Heart rate monitor:**
   - Strap on the heart rate monitor under your breastplate as shown in training
   - Make sure the sensor side is in contact with your skin (put a few drops of water on the sensors so they make better contact with your skin)
   - The Garmin logo should be facing outward
   - The Garmin logo should be right side up
4. **Start tracking:**
   - After following the previous steps press the start/stop button under the display screen
   - Go about your normal activities for the testing period
   - ***If the heart icon with numbers next to it (heart beats per minute) does not appear in the upper right hand of the screen, then press the mode**

**button → use the arrow buttons to navigate to settings → press enter → general should be highlighted → press enter use arrow buttons to scroll to accessories → press enter → use arrow buttons to highlight restart scan → press enter**

**a.** Press mode button until you are back at starting screen

**b.** Check to see if the heart icon, when active it should have numbers next to it

5.**Alert messages:**

- The most common message → message on display screen signaling that satellite reception has been lost (mostly occurs indoors, away from windows)
- Press the enter button and continue with normal activities

6. **End tracking:**
   - Press the start/stop button a second time at the end of your testing period

* **Problems:**
   - If you experience any problems with the GPS unit or have any questions regarding the study, please contact me immediately at *.

# APPENDIX D

# AUDIO DIARY INSTRUCTIONS

## Audio Diary Instructions

The audio diary component of this study is important for interpreting the data collected from the GPS unit and synched heart rate monitor. Participation in this study requires your diligence in the timely recording of several factors during the three periods that I will be tracking you. During each diary entry, **please include the time, your location, and the duration of the event/experience if possible**.

**You should record the following events...**

1. Times when you feel stressed and the situation or environment related to/causing your stress - examples: running late for class, walking home alone late at night, cramming for an exam, etc.
   a) What is the particular constraint associated with your stress? Choose one of the following: a) something imposed by an authority figure (professor, boss, parent) b) a limitation of your own biological ability (physical, mental), or c) a situation related to activities that require other people to be involved.
   b) If the stress that you are feeling is environmental, is it related to how you feel about or perceive a particular place? Please explain why you feel stress in that place or what the place means to you.
2. Any periods of physical exertion – examples: exercise, yelling for your favorite team, jumping up and down with excitement, playing Nintendo Wii, etc.
3. Ingestion of substances that might affect your heart rate – examples: spicy food, coffee, tea, alcohol, nicotine, drugs, etc.
4. Periods spent indoors when GPS signal is lost – where you are (locations) and what you are doing (generally unless it applies to a recordable factor)
5. Any periods of excitement or positive challenge – examples: winning the lottery, solving an interesting problem

**Test Session # 1:**

a) 5 hour duration

b) Establishing baseline heart rate

c) In addition, note any time spent resting/relaxing

**Test Session # 2:**

- 10 hour duration

**Test Session # 3:**

- 10 hour duration

# APPENDIX E

## PARTICIPANT SURVEY

**Participant Survey**
Student Stress Exposure: A Life Path Perspective on the Connections between Time-Locational Sequence, Place, and Stress

**Name:** _____ **Date:** _____

**Instructions:** please answer the following questions.

1) Male or Female? M F
2) Age: _____
3) Are you married? Y N
4) What degree are you currently working on (what major)?

   _____

5) How many years have you been working on this degree? _____
6) Are you a full-time student? Y N
7) How many credit hours are you currently taking? _____
8) When do you expect to graduate? _____
9) Do you support yourself financially? Y N

If yes, what position do you hold, how many hours a week do you work, and where do you work?

10) How long have you attended Texas A & M University? _____
11) How long have you lived in the Bryan/College Station area? _____

12) Are you disabled? Y N

If yes, please give a brief description of your disability.

13) Do you have a history of high or low heart rate? Y N Maybe

14) Do have any sort of illness (i.e. cardiovascular, asthma, etc.) or condition that might affect your heart rate? Y N Maybe

If yes or maybe, please explain.

15) Are you currently taking any medications? Y N

If yes, what medications? What is the medication for?

16) Do you smoke? Y N

17) Do you drink caffeine or take any type of stimulant that might affect your heart rate? Y N

18) Have you been diagnosed with mental illness (i.e. depression, anxiety, post-traumatic stress syndrome, etc.)? Y N

19) How do you define stress?

20) Do you consider yourself stressed? Please explain why or why not.

21) Are there particular places (locations) on campus that cause you to feel stressed? If so, what are the places and why do they cause you to feel stressed?

22) How do you react to stressful situations?

23) What do you do to cope with the stress in your life?

24) Do you think that you have good coping skills? Y N

25) Do you think that stress adversely affects your health on a regular basis? Y N

Maybe

If Yes or Maybe, can you describe 1 or 2 examples in your life?

26) What situations (constraints) do you think cause the majority of your stress?

- Capability issues (biological, physical limitations)
- Coupling issues (tasks that have to performed with other people)
- Authority issues (things that are required by a boss, parent, the government, etc.)

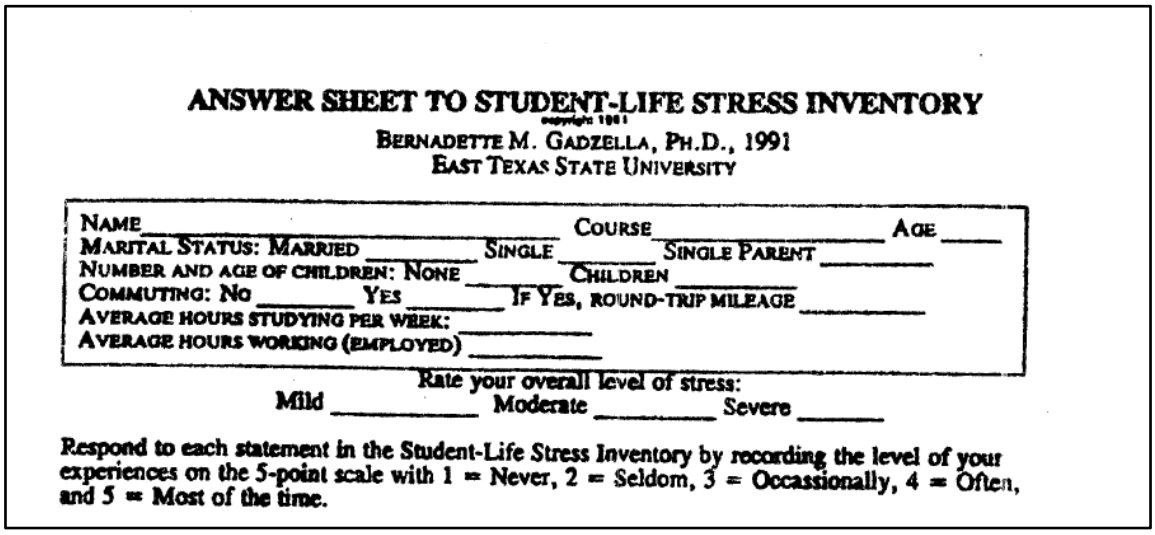
Please explain your choice.

27) How do you feel about being tracked with a GPS unit and heart rate monitor?

28) Do you have any privacy concerns? Y N

# APPENDIX F

## STUDENT-LIFE STRESS INVENTORY



**ANSWER SHEET TO STUDENT-LIFE STRESS INVENTORY**



BERNADETTE M. GADZELLA, PH.D., 1991
EAST TEXAS STATE UNIVERSITY

NAME_____ COURSE_____ AGE ____
MARITAL STATUS: MARRIED _____ SINGLE _____ SINGLE PARENT _____
NUMBER AND AGE OF CHILDREN: NONE _____ CHILDREN _____
COMMUTING: NO _____ YES _____ IF YES, ROUND-TRIP MILEAGE _____
AVERAGE HOURS STUDYING PER WEEK: _____
AVERAGE HOURS WORKING (EMPLOYED) _____

Rate your overall level of stress:
Mild _____ Moderate _____ Severe _____

Respond to each statement in the Student-Life Stress Inventory by recording the level of your experiences on the 5-point scale with 1 = Never, 2 = Seldom, 3 = Occassionally, 4 = Often, and 5 = Most of the time.

**Figure 119.** Student-Life Stress Inventory demographics survey, stress level self-rating, and questionnaire instructions.

I. STRESSORS:

A. As a student:
1. I have experienced frustrations due to delays in reaching my goal.
2. I have experienced daily hassles which affected me in reaching my goals.
3. I have experienced lack of sources (money for auto, books, etc.)
4. I have experienced failures in accomplishing the goals that I set.
5. I have not been accepted socially (became a social outcast).
6. I have experienced dating frustrations.
7. I feel I was denied opportunities in spite of my qualifications.

B. I have experienced conflicts which were:
8. Produced by two or more desirable alternatives.
9. Produced by two or more undesirable alternatives.
10. Produced when a goal had both positive and negative alternatives.

C. I have experienced pressures:
11. As a result of competition (on grades, work, relationships with spouse and/or friends).
12. Due to deadlines (papers due, payments to be made, etc.)
13. Due to an overload (attempting too many things at one time).
14. Due to interpersonal relationships (family and/or friends expectations, work responsibilities).

D. I have experienced:
15. Rapid unpleasant changes.
16. Too many changes occurring at the same time.
17. Changes which disrupted my life and/or goals.

E. As a person:
18. I like to compete and win.
19. I like to be noticed and be loved by all.
20. I worry a lot about everything and everybody.
21. I have a tendency to procrastinate (put off things that have to be done).
22. I feel I must find a perfect solution to the problems I undertake.
23. I worry and get anxious about taking tests.

**Figure 120**. Student-Life Stress Inventory part I: stressors questions.

II. REACTIONS TO STRESSORS:

F. During stressful situations, I have experienced the following:
- 24. Sweating (sweating palms, etc.)
- 25. Stuttering (not being able to speak clearly).
- 26. Trembling (being nervous, biting finger-nails, etc.)
- 27. Rapid movements (moving quickly from place to place)
- 28. Exhaustion (worn out, burned out)
- 29. Irritable bowls, peptic ulcers, etc.
- 30. Asthma, bronchial spasms, hyperventilation
- 31. Backaches, muscle tightness (cramps), teeth-grinding]
- 32. Hives, skin itching, allergies.
- 33. Migraine headaches, hypertension, rapid heartbeat.
- 34. Arthritis, overall pains.
- 35. Viruses, colds, flu.
- 36. Weight loss (can't eat)
- 37. Weight gain (eat a lot)

G. When under stressful situations, I have experienced:
- 38. Fear, anxiety, worry
- 39. Anger
- 40. Guilt
- 41. Grief, depression

H. When under stressful situations, I have:
- 42. Cried
- 43. Abused others (verbally and/or physically)
- 44. Abused self (use of drugs, etc.)
- 45. Smoked excessively
- 46. Was irritable towards others
- 47. Attempted suicide
- 48. Used defense mechanisms
- 49. Separated myself from others

I. With reference to stressful situations, I have:
- 50. Thought and analyzed about how stressful the situations were.
- 51. Thought and analyzed whether the strategies I used were most effective.

**Figure 121**. Student-Life Stress Inventory part II: reaction to stressors questions.

# APPENDIX G

## STUDENT-LIFE STRESS INVENTORY

**Table 29.** SSI stressor type scores

| ID | Frustration Percent | Conflict Percent | Pressure Percent | Change Percent | Self-Imposed Percent | Stressor Score | Score Percent |
|---|---|---|---|---|---|---|---|
| 201 | 48.50 | 53.30 | 75.00 | 40.00 | 86.60 | 72 | 62.60 |
| 202 | 40.00 | 46.60 | 75.00 | 53.30 | 80.00 | 68 | 59.10 |
| 203 | 54.20 | 66.60 | 85.00 | 33.30 | 60.00 | 69 | 60.00 |
| 204 | 51.40 | 60.00 | 95.00 | 20.00 | 86.60 | 75 | 65.20 |
| 205 | 48.50 | 66.60 | 70.00 | 53.30 | 66.60 | 69 | 60.00 |
| 206 | 54.20 | 66.60 | 90.00 | 53.30 | 86.60 | 81 | 70.40 |
| 207 | 57.10 | 60.00 | 60.00 | 40.00 | 76.60 | 70 | 60.80 |
| 208 | 42.80 | 46.60 | 70.00 | 66.60 | 66.60 | 66 | 57.30 |
| 209 | 65.70 | 73.30 | 80.00 | 46.60 | 83.00 | 82 | 71.30 |
| 210 | 60.00 | 80.00 | 100.00 | 46.60 | 100.00 | 90 | 78.20 |
| 211 | 40.00 | 60.00 | 65.00 | 33.30 | 80.00 | 65 | 56.50 |
| 212 | 37.10 | 66.60 | 85.00 | 46.60 | 73.30 | 69 | 60.00 |
| 213 | 45.70 | 53.30 | 85.00 | 40.00 | 93.00 | 75 | 65.20 |
| 214 | 42.80 | 73.30 | 80.00 | 33.30 | 86.60 | 73 | 63.40 |
| 215 | 34.20 | 66.60 | 90.00 | 73.30 | 90.00 | 78 | 67.80 |
| 216 | 54.20 | 73.30 | 90.00 | 93.30 | 80.00 | 86 | 74.70 |
| 217 | 37.10 | 60.00 | 70.00 | 40.00 | 50.00 | 57 | 49.50 |
| 218 | 54.20 | 53.30 | 100.00 | 60.00 | 50.00 | 71 | 61.70 |
| 219 | 34.20 | 66.60 | 75.00 | 66.60 | 96.60 | 76 | 66.08 |
| 220 | 54.20 | 20.00 | 80.00 | 73.30 | 90.00 | 76 | 66.80 |
| 221 | 42.80 | 60.00 | 60.00 | 46.60 | 76.60 | 66 | 57.30 |
| 222 | 37.10 | 60.00 | 65.00 | 40.00 | 90.00 | 68 | 59.10 |
| 223 | 42.80 | 60.00 | 45.00 | 20.00 | 73.30 | 58 | 50.40 |

**Table 30**. SSI reaction type scores

| ID | Physiological Percent | Emotional Percent | Behavioral Percent | Reflection Percent | Reaction Score | Score Percent |
|---|---|---|---|---|---|---|
| 201 | 50.00 | 45.00 | 30.00 | 60.00 | 62 | 44.20 |
| 202 | 58.50 | 50.00 | 30.00 | 20.00 | 65 | 46.40 |
| 203 | 68.50 | 55.00 | 60.00 | 90.00 | 92 | 65.70 |
| 204 | 31.40 | 50.00 | 30.00 | 20.00 | 46 | 32.80 |
| 205 | 61.40 | 45.00 | 35.00 | 60.00 | 72 | 51.40 |
| 206 | 42.80 | 85.00 | 60.00 | 20.00 | 73 | 52.10 |
| 207 | 48.50 | 60.00 | 32.50 | 40.00 | 63 | 45.00 |
| 208 | 35.70 | 70.00 | 35.00 | 50.00 | 58 | 41.40 |
| 209 | 47.10 | 70.00 | 32.50 | 60.00 | 66 | 47.10 |
| 210 | 67.10 | 100.00 | 57.50 | 60.00 | 96 | 68.50 |
| 211 | 38.50 | 45.00 | 27.50 | 40.00 | 51 | 36.40 |
| 212 | 48.50 | 65.00 | 42.50 | 60.00 | 70 | 50.00 |
| 213 | 45.70 | 55.00 | 27.50 | 40.00 | 58 | 41.40 |
| 214 | 47.10 | 55.00 | 40.00 | 80.00 | 68 | 48.50 |
| 215 | 32.80 | 70.00 | 25.00 | 40.00 | 51 | 36.40 |
| 216 | 64.20 | 85.00 | 67.50 | 80.00 | 97 | 69.20 |
| 217 | 37.10 | 40.00 | 25.00 | 50.00 | 49 | 35.00 |
| 218 | 64.20 | 60.00 | 42.50 | 70.00 | 81 | 57.80 |
| 219 | 32.80 | 65.00 | 40.00 | 50.00 | 57 | 40.70 |
| 220 | 42.80 | 75.00 | 57.50 | 40.00 | 72 | 51.40 |
| 221 | 35.70 | 40.00 | 27.50 | 80.00 | 52 | 37.10 |
| 222 | 42.80 | 60.00 | 32.50 | 60.00 | 61 | 43.50 |
| 223 | 38.50 | 60.00 | 35.00 | 40.00 | 57 | 40.70 |

# APPENDIX H

## AUDIO TRANSCRIPTS: PARTICIPANTS 203 AND 205

### Participant 203

Entry 1: 11/11/09 8:49
Okay so um it's about 8:45, a little after 8:45 in the morning and I am walking briskly to work (laughs) which is about a 10-15 minute walk from my dorm um. And I'm a little stressed because I think I'm going to be late...cause I'm always late so.
→ Can hear heavy breathing and rustling (possibly clothing or environmental noise)

Entry 2: 11/11/09 8:50
Um I guess I should identify that as a (repeated) biological factor (repeated).
→ referring to 1st entry?

Entry 3: 11/11/09 10:05
Okay it's a little bit after 10 o'clock um and I just got out of a work meeting where I was sitting down the whole time so my heart rate was probably low. And I'm about to get some coffee, which might raise my heart rate um.

Entry 4: 11/11/09 12:34
Alright, it's about 12:40 and I just took a nap um for like 20 minutes on the grassy knoll and I'm about to go back to class.
→ In the background you can faintly here a female voice say something like "...in a hurry."

Entry 5: 11/11/09 12:35
And to add to that I'm not feeling very stressed right now. Mostly I just sit around in class and take notes (laughs) when I'm not in class. So I haven't had a lot of stress.
→ Can here background bird songs.

Entry 6: 11/11/09 14:11
Okay, Nikki um I had, that was the end of my 1st, I guess the test session number one which is only 5 hours and I went back and listened to all of my recordings and I realized that I could have been a lot more specific and I didn't always include my location and everything like that. So I think that I'm going to definitely do better for the next two test sessions. But for now I'm going to back and specify different things about each recording. So um for the 1st recording this morning I was leaving my dorm on Northside. I live in Neely um and that was about 8:45 and I was walking to my work, which is at the library.

Um and then as far as the 2nd recording I was sitting down in a work meeting from 9 to about 10. I made the 2nd recording after 10 o'clock when I went down um from the library to the coffee shop outside the library to get coffee. Um so then...lets see...I had class at 11...I took a nap in the library...um and then I had class um well from 10 to 11:30 I guess I was in the library. Then at 11:30 I walked to the O&M Building which is where I had class. Um I went to one class and then I um took a nap outside on the grassy knoll and that's when I made the 4th recording. So pretty much I was just sitting in class and then I walked outside and took a nap in the sun. And then um at 12:40 I went back and ah sat in class some more. So hopefully um that helps. I had two classes in O&M that day so um yeah. I hope that this is a little bit more specific and during the 10-hour durations, I will be a little more vocal about what I'm feeling and specific times that I feel stressful

Entry 7: 11/12/09 8:42
Okay it's about 8:40 and I'm in the library. Um I got coffee which has caffeine and might increase my heart rate. Actually, I got double espresso (laughs) in my coffee which might raise my heart rate a lot.

Entry 8: 11/12/09 8:43
Tapping and crinkling (repetition)
→ ???

Entry 9: 11/12/09 11:14
Okay, it's about 11:15 and I'm still in the library. Um I just got off work and I wasn't very stressed at work. It's a really relaxed environment um and I feel confident in my abilities. I work at the writing center. Um so I you know...work is not stressful for me. Um I think because I... you know I know what to do. I feel confident in myself. So I'm usually really relaxed at work. Um but I'm still in the library and now I'm feeling a little bit more stressed because I have a test in about three hours um and I'm still learning the material for it. And this is a big test because it will determine if I make a B or a C in my calculus class. I really want a B um (laughs). So that's why I'm feeling stressed right now because I have to learn everything. Um so I'm going to be here for the next three hours just studying and practicing. And I guess I'll identify this as a um hum maybe an authority stress because (laughs) because I have to do this for my professor to give me a B. Um yeah so as far as this place, I'd say that the library is kind of a stressful place for me because I'm always cramming here and this is where I come when I really need to concentrate and when I'm under a lot of pressure.
→ Contradicting place meaning

Entry 10: 11/12/09 14:12
Okay, it's about 2:20 um in the afternoon and I'm um at the Civil Engineering Building (sighs) um I'm about to go take my test. And I'm feeling under a lot of stress right now because I'm about to go take my test and everyone in my class, which has like ten people, um everyone is talking about numbers and different formulas that no one

understands and I'm afraid that they are going to um confuse me because I feel really solid on the material now that I studied. But I...I just get stressed out when everyone is talking at once um and whenever there are a bunch of people and there's a lot of noise(laughs). Um so that's stressing me out a little bit and I'm going to try not to let it get to my head. So I came outside where it's quiet and where I can go over all the material in my head.
→ Can hear background talking and then outside traffic noise

Entry 11: 11/12/09 14:13
And I think I should identify that as a coupling, I guess um (repeats)...cause it has to do with...(inaudible)

Entry 12: 11/12/09 15:42
It's about 3:35 and I'm leaving the Civil Engineering Building where I just had my math test. I was under probably some of the most stress I've ever felt. And um I've been having like test anxiety lately especially when it comes to math. And it was...the test I knew all the material but I got stuck on this one problem because I made a careless mistake and then it took up so much time and I completely I mean was like hyperventilating in the test room (laughs). Um so that was horrible um and I guess I'll call that authority stress because my professor was like standing right there watching me and um you know she was there to take up the test and everything. So I'll call that authority. But um yeah so I'm walking back to my dorm in Neely.
→ Traffic noise in the background
→ Authority or should it biological because of test anxiety

Entry 13: 11/12/09 17:34
Okay it's about 5:30 and right now I'm exiting my parking garage which is on Northside. Um I'm on my way to ultimate frisbee practice for my ultimate frisbee team and so that should raise my heart rate cause I'll be running around quite a bit I think for the next few hours. Um...yeah so I, I'm not feeling too stressed right now, nothing in particular. I got over how horrible my math test was so (laughs). Hopefully, I'm better from that.

Entry 14: 11/12/09 17:36
I think I should mention that if I am feeling stressed right now um, which is a little bit...I don't know, um it's because I never give myself enough time to do things. That's something that I've noticed. Like my practice started at 5:30 and I'm already about 10 minutes late for it. Um so I think most of my stress, I'll call it biological because I don't physically allow myself the ability or the room to do things that I need to get done and be places that I need to be. And so I end up getting pretty stressed and feeling like I never have enough time and feeling like I'm under so much pressure. Um so I'm not sure if that really counts as biological because it's not like a physical...it's not like a true physical limitation it's something that I kind of impose upon myself just with my lifestyle.

Entry 15: 11/13/09 15:02
No number 15 entry???

Entry 16: 11/13/09 16:05
It's about 3 o'clock on Friday and um I'm just starting my 10 hour 2nd test period, um well I guess 3rd test period because I woke up really late today and then I was wearing the heart monitor upside down (laughs)...um yeah. So that was kind of weird but once I figured that out um I'm starting it now. And I am about to go um to my boyfriends house and then we are going to drive to Houston to see his parents. Um and then all weekend I have a frisbee tournament in Houston so I'm feeling a little stressed about that just about like the you know that pressure in the future because I want to play well and I know people are going to be watching me and people are going to be either putting on the field or not putting me on the field. And um yeah so that's a little bit stressful for me. But other than that I skipped all my classes today um and I'm going to do some reading that I need to do on the way to Houston. So I'm not feeling particularly stressed right now. Just about this weekend and maybe a little bit stressed about hanging out with my boyfriends parents tonight because I know them but I'm a little bit intimidated by parents sometimes. So that's how I'm feeling right now and I think both of those stresses that I identified are coupling because they definitely have to do with other people.

Entry 17: 11/16/09 23:45
Okay it's 4:07 and I'm driving to Houston with my boyfriend and we just passed a spot where I got um pulled over over summer. And I had to pay five hundred dollars for a speeding ticket um and there was also a cop here at the same time (laughs). So that made me nervous and I always get nervous when I see cops ever since I got that ticket. But we just passed the same spot but that I got pulled over at that time. Okay, oh and that was an authority stress.
→ An authority stress but also because she remembers the exact spot there's also a sense of place meaning
→ Road noise audible

Entry 18: 11/16/09 23:47
Okay um I was at my boyfriends house um I'm actually home right now but this is the only chance I had to record this. So um while I was at my boyfriends house I was in Houston, which I'm sure will show up on the GPS. Um but that was a little bit stressful. Um I felt some I guess coupling stress because just hanging out with his parents and we played like a card game that I didn't know how to play. Um and so I felt a little bit of pressure to you know to be able to learn the game quickly and um you know just to not feel stupid (laughs). Um so I think that that was a slight source of stress. Um but other than that, as far as the place, um being at that house is not very stressful because I have good memories there. Um and I feel I feel mostly comfortable around his family. Yeah so I just wanted to say that I did have a little bit of stress while I was kind of in a what I would consider slightly like pressured situation but other than that there wasn't very much stress.

→ Retrospective
Entry 19:
And this is and this is Friday night...forgot to mention forgot to mention.

**Participant 205**

Entry 1: 11/11/09 8:24am
Well good morning this is my first day to do this. Ah, um, it took me a minute to get the (pause) heart thingy to work. So, we might have a little misreading at the very beginning. Ah, I'm getting ready to go to a meeting. So, I'll keep you posted throughout the day. So, bye.

Entry 2: 11/11/09 8:37am
Waiting on the bus (footsteps in background).

Entry 3: 11/11/09 8:50am
So, I just got off the bus, I'm running a little late to my meeting. Soooo I'm going to have to do this. (sounds out of breath) And, I'm walking a little fast.

Entry 4: 11/11/09 10:03am
So I guess to recap what I've missed. Ah, I had my meeting with my advisor at 9. That lasted for about 15 minutes. I'm really excited about getting my teaching certificate on top of my Meteorology (pause) major. So, I was a little excited that time. Ah, I talked to my dad (pause) on the phone talking about it, so still excited. Ah, I just got off the (pause) got on the bus, got off the bus, came home. And I'm walking to my (pause) to the sorority house right now. So, (out of breath) and I'm about to go start getting my classes in order for the next, (unclear) rest of the year. So, there you go.

Entry 5: 11/11/09 10:43am
Just to let you know, I'm in the sorority house. Um, Ah, It says that it can't find me. So, just to let you know.

Entry 6: 11/11/09 11:05am
(unclear)… to the bus stop. (Talking out of breath) Again, I'm running a little late (pause) to class. So, I'm about to go do my dance class from 11:30 to ah, 12:25. So (shuffling sound in background).

Entry 7: 11/11/09 12:21pm
Just finished dance class; really tired (emphasized) by the way. Going back home. And I have to do a couple of errands. So, there you go.

Entry 8: 11/11/09 12:55pm
Getting in the truck to go run errands.

Entry 9: 11/11/09 (13:21) 1:21pm
So I just got back from doing my errand, I got the tux for my boyfriend ah, for the wedding this week, weekend. Ah, overall today was a good day. I didn't feel that stressed; ah, a lot of ah, movements; you know walking fast and dancing. Ah, I was a little excited about getting my teaching certificate, a little, but also a little stressed out about that cause it'll be adding an extra year on. Ah, Also, I thought a lot about ah, our election for my sorority is coming up so I thought about a lot of that. So, if you saw a random jump it could have been me thinking about that. Ah, it's not really stressful but you know getting voted into something; hoping and praying that you get voted into something can be a little stressful sometimes. (Big sigh) That was just ah, just my day, ah, So, I'm about to take this off for my first 5 hours for the first day. And, I guess I'll talk to you tomorrow. Goodbye (cheerful tone of voice).

Entry 10: 11/12/09 6:47am
Having real trouble with the device. I would get my heart beat and then I would start it and like not get it. So, I'm having trouble getting my heartbeat. Ah, I have wiped it down. And I will wipe it down again. So, that is why if you see off and on and off and on and it not really matching at the very beginning. So, I'm trying to get this thing to work. So.

And also, ah, part of my survey says (long sigh) I have really bad stomach problems, or stomach pains. Ah, (sigh), I get really bad indigestion. Like really bad, like I curl up in a little ball, like I want to die. That happened last night. So, I am still in pain right now. I don't know what that will do with my heart rate. Just to let you know. I will let you know when the pain stops. But, it usually lasts for a long time. It has lessened. I don't, I'm not, I can actually walk around (pause) but it still really hurts. And, it's (sigh) still (pause) means I won't be going to class. But, I probably will. So, I'll keep you posted.

Entry 11: 11/12/09 7:03am
Walking to the bus now. Ah… (Gasping as in pain, trembly voice) still in pain. Pain's probably around a 4 or 5 on a scale of 1 to 10, 10 being the worst. And, ah, it sometimes peaks to 6 according to if I move too quickly or not. Ah, I've taken everything under the sun I can think of to stop this. And my doctors and (unclear) thinks its stress. I think I have (pause) there's something else wrong with me. Because I was not, I didn't think I was stressed at all yesterday; I mean I might of, my, excited stress but not like bad stress. (Seems out of breath or in pain). I don't know. Ah, maybe this thing will figure it out. Ah, (sigh) well. Keep you posted.

Entry 12: 11/12/09 7:33am
So I don't think I hit the start button when right when I was supposed to. So, Stuff I might have told you might not (…unclear…) actually I'm not feeling good right now. I'm not. So, the first part of (…unclear…) is probably not going to make no sense to you. I'm very sorry. So, Hopefully, I cannot screw up from now on. So, I just, I got off

the bus and I'm walking to my next class, or my first class I guess I should say. The pain is still about a 5. Ah, so, just to let you know (sounds really distressed).

Entry 13: 11/12/09 (13:04) 1:04pm
Okay, so let me recap what happened because I've, haven't been able to talk in a saneness since this morning. Okay, (pause) excuse me. So I woke up sick, you know this. Ah, I guess at 7:30 I got to into my classroom, studied for a quiz, always have a quiz in the morning. Quiz started around 8:05. So if my, ah, heart rate went up then. Ah, Class until 9:15 walked to my next class which was 9:35. Oh in that class I was suppose to get my test back but he had not yet graded. Ah, after that class got over at 10:50, I had to hurry to catch the bus to get to my next class which is on west campus. That class started at 11:10. I probably got there around 11:00 (pause) 11:05; somewhere between there. Ah, then we did get a test back in there. I probably got (pause), we were, no, we were supposed to get our test back in there. Everyone else did but me; ah, he had lost my test. So, if my temperature is a little bit, my heart rate a little bit raised because of that, that why. Ah, then I had to catch a bus, walk across the campus to catch a bus, come back to Sorority house probably around 12:45ish, Ate lunch. Now, I'm going to pick up my room, pack, and I'll either take a nap or go get my nails done. So, I'll keep you posted.

Entry 14: 11/12/09 (13:04) 1:04pm
Actually I'm going to take a short break right now. I'm really tired. So, there you go.

Entry 15: 11/12/09 (13:06) 1:06pm
Sorry, if I also, I also forgot to tell you where my classes were. My first class was in the Civil Engineer building, my second class was in Blocker. My third was in the Hort (horticulture) building. And, now I am back in my Sorority House. So, just to let you know.

Entry 16: 11/12/09 (15:57) 3:57pm
So I am terribly sorry, my (…unclear…) nap turned into a 3 hour nap. In my defense I didn't feel good last night, I didn't sleep very much, I know my body needed it. So, (pause) there you go. I'm going to get up, start packing (pause) and we'll (pause) go from there. So there you go.

Entry 17: 11/12/09 (17:12) 5:12pm
I got done packing and I'm about to start loading my truck.

Entry 18: 11/12/09 (17:23) 5:23pm
Finished loading my truck. I think I'm going to go get my nails fixed before I head out. So, (sigh) ah, I guess I'll turn off on getting my (…unclear…) done cause I've only got 10 minutes left. So, I hope this helps.

Entry 19: 11/16/09 8:42am
Okay, it's Monday morning. I know you wanted to get three ah, days in a row. Well what happened was I went to Huntsville with my boyfriend to go to Dallas for his brother's wedding. I left this thing in Huntsville. So we didn't get back until Sunday night so it wasn't any point in starting it then, so I'm starting it Monday morning. I'm still here in Huntsville. My class doesn't start until 11:30. I plan on leaving here in about 30 minutes. So right now I'm packing up getting dressed to go drive back to College Station. Sorry for the big confusion. So, right now I am in Huntsville. It's not seeing me, ah; it should be right where I left off in the apartment complex in Huntsville. So, ah, um, I guess I can tell you when I'm going to start driving.

Entry 20: 11/16/09 9:04am
I just loaded my truck. I'm about to leave Huntsville to go back to College Station. So, I'll keep you posted.

Entry 21: 11/16/09 9:17am
Okay, there's a chance right now that my heart beat will be getting a little peaked, because ah, I was thinking about, I have a project due tomorrow. All my stuff (pause); a group project. All my stuff I have needed to do for this group project; it's done. I just need to ah, critique it, ah; you know; make it a little more (pause) presentable and put, put a little into a Power point, a PowerPoint presentation, a little bit (sounds a little anxious). It's about planets and the planets' atmosphere and what we can learn from the planets' atmosphere. (AChoo!)

Entry 22: 11/16/09 10:03am
Back to College Station, back in the Sorority House. I'm gonna unload (sigh), hopefully get some of my email checked and see if they emailed me (sigh) ah, and then go to class.

Entry 23: 11/16/09 10:03am
I did the whole entire drive. The thing hadn't started. I thought I hit start but apparently not. So, I just now hit start. So, I don't know if you need all the other information. So, I don't know if it was recording or not. So, I guess my time starts now at 10. So, okay, bye.

Entry 24: 11/16/09 10:56am
Walking to the bus to wait to go to class. So, I emailed my stuff in (sounding a little out of breath). So, hopefully she'll respond, because my heart is probably still racing because I'm nervous about that. So just, so now I'm about to go dance so my heart rate will go up.

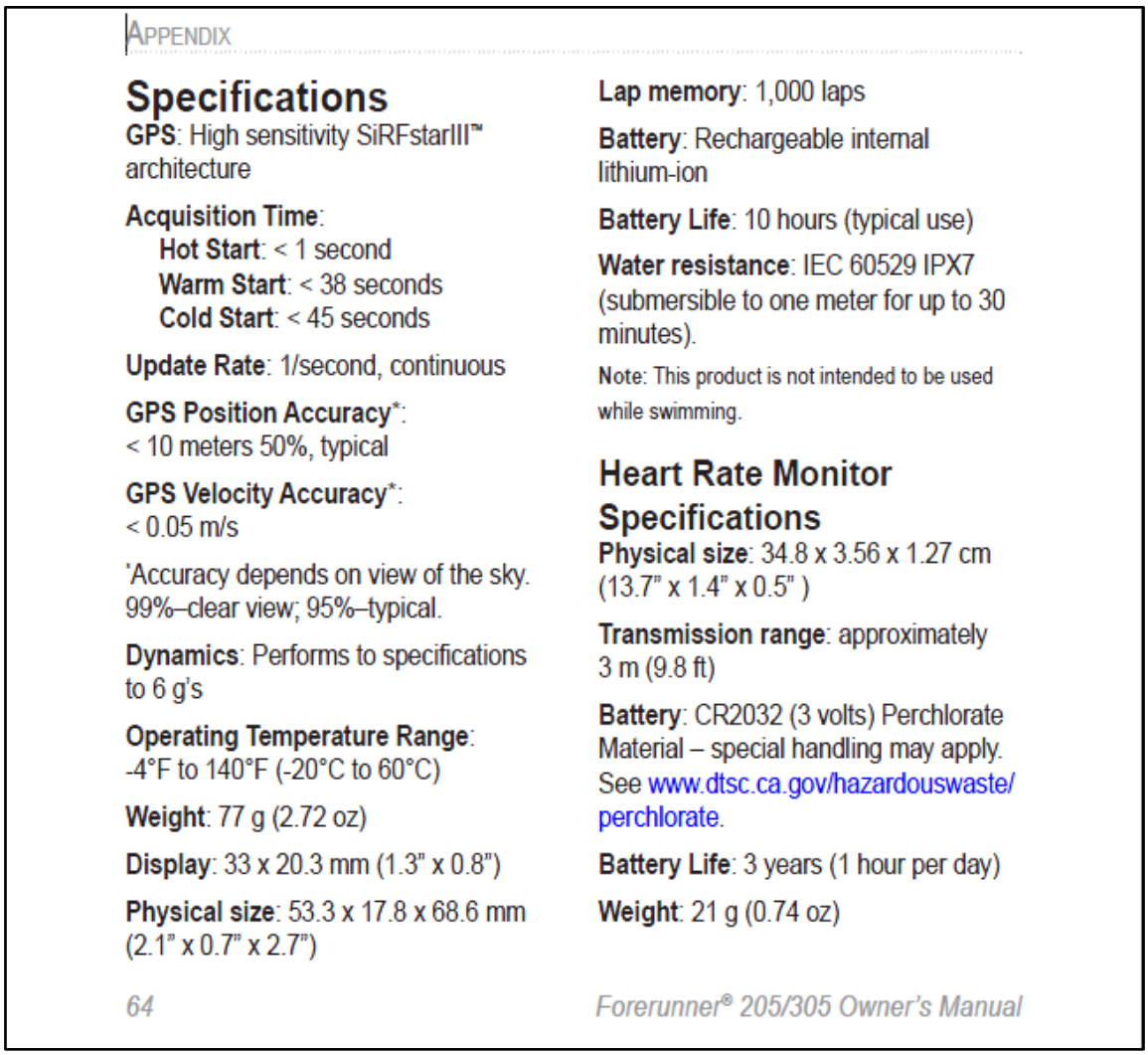
Entry 25: 11/16/09 (16:58) 4:58pm
So here, let me catch you up with some stuff. Ah, I danced from 11:30 to 12:45 at G. Rollie White, came back to the Sorority House, ah, ate dinner, er lunch whatever; food, lunch, ah, talked about the election we are having tonight for my sorority. Ah, went back

to class from 3 to 3:50, rode on the bus, came back. Ah, during the class my, ah, too, my heart rate might have been a little higher because I was worried about my project group members weren't coming up. I still hadn't gotten something from one person, but I had gotten something from the others. So, we'll see (with emphasis). So, ah, heart rate will be, er probably a little quick (pause) today at meeting because we vote. So, we'll see how, what everything works out. So, I'm sorry (pause) to take so long to do this. But, there you go.

Entry 26: 11/16/09 (21:47) 9:47pm
This is my last day to do it. Ah, I don't think I've dictated to this. Soon as I got back from class, I got dressed, ate dinner ah, and I went to my sorority meeting. Ah, my heart rate might have gone up in there a couple time cause we did vote. So, if you see a little random spike it was because I was a little excitement about voting. Ah, then after meeting we went and had ice cream, and then went to Target. So, I think that's it, I'm done. Have fun, bye.

# APPENDIX I

## GARMIN GPS SPECIFICATIONS



APPENDIX

### Specifications

**GPS**: High sensitivity SiRFstarIII™ architecture

**Acquisition Time**:
- **Hot Start**: < 1 second
- **Warm Start**: < 38 seconds
- **Cold Start**: < 45 seconds

**Update Rate**: 1/second, continuous

**GPS Position Accuracy***:
< 10 meters 50%, typical

**GPS Velocity Accuracy***:
< 0.05 m/s

*Accuracy depends on view of the sky. 99%–clear view; 95%–typical.

**Dynamics**: Performs to specifications to 6 g's

**Operating Temperature Range**:
-4°F to 140°F (-20°C to 60°C)

**Weight**: 77 g (2.72 oz)

**Display**: 33 x 20.3 mm (1.3" x 0.8")

**Physical size**: 53.3 x 17.8 x 68.6 mm (2.1" x 0.7" x 2.7")

**Lap memory**: 1,000 laps

**Battery**: Rechargeable internal lithium-ion

**Battery Life**: 10 hours (typical use)

**Water resistance**: IEC 60529 IPX7 (submersible to one meter for up to 30 minutes).

Note: This product is not intended to be used while swimming.

### Heart Rate Monitor Specifications

**Physical size**: 34.8 x 3.56 x 1.27 cm (13.7" x 1.4" x 0.5" )

**Transmission range**: approximately 3 m (9.8 ft)

**Battery**: CR2032 (3 volts) Perchlorate Material – special handling may apply. See www.dtsc.ca.gov/hazardouswaste/perchlorate.

**Battery Life**: 3 years (1 hour per day)

**Weight**: 21 g (0.74 oz)

64 Forerunner® 205/305 Owner's Manual

**Figure 122.** Garmin Forerunner 305 GPS/HR unit specifications.

# APPENDIX J

## RCA DIGITAL VOICE RECORDER SPECIFICATIONS

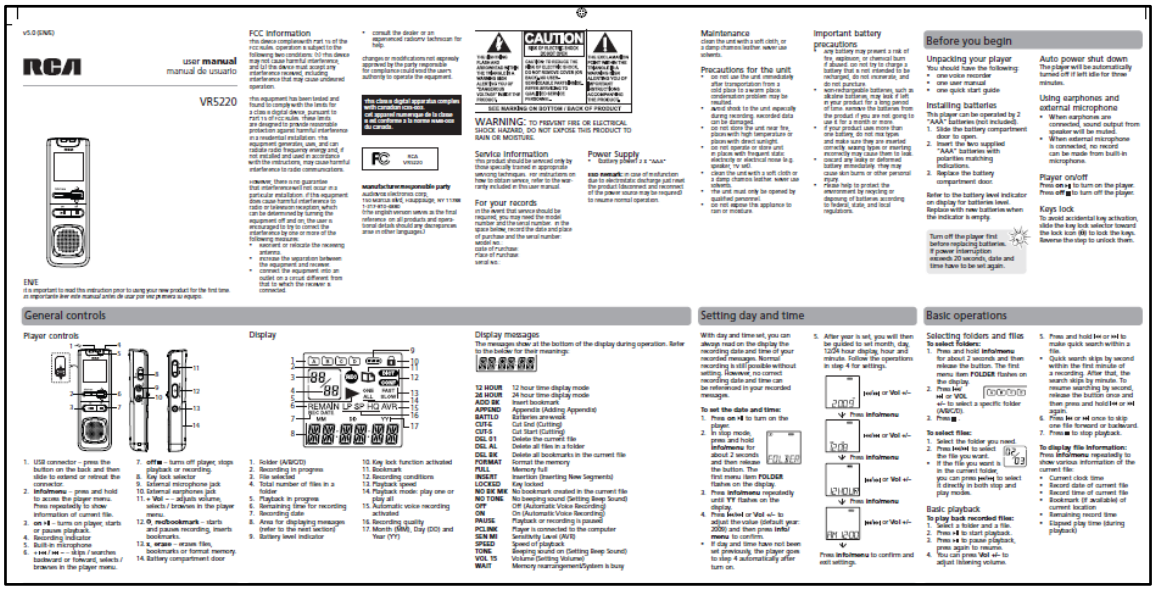


**Figure 123a**. RCA VR5220 digital audio recorder specifications (1 of 3).

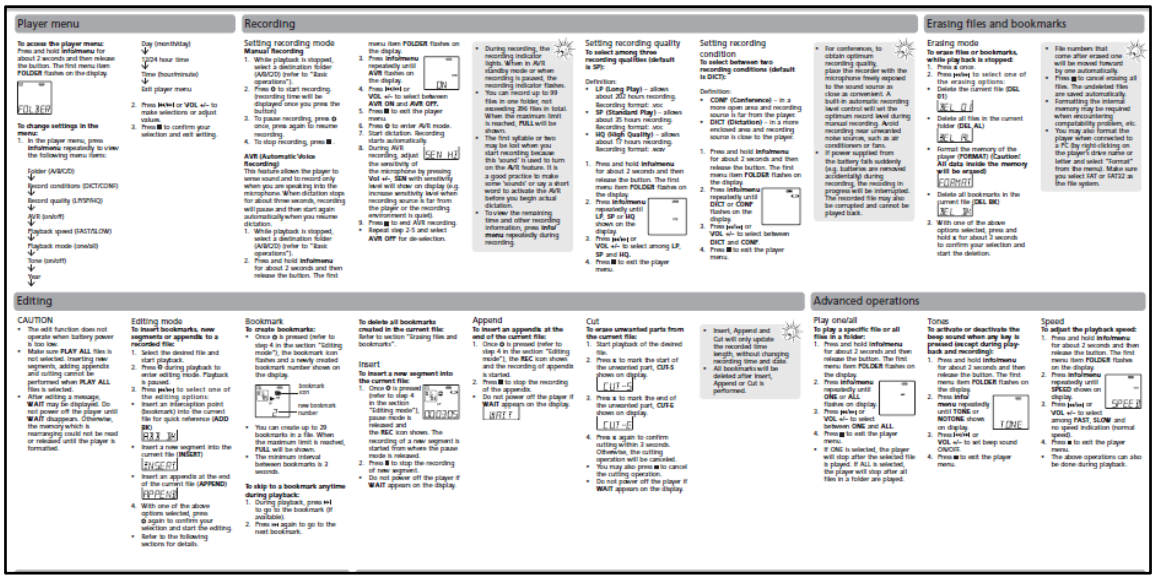



**Figure 123b**. RCA VR5220 digital audio recorder specifications (2 of 3).

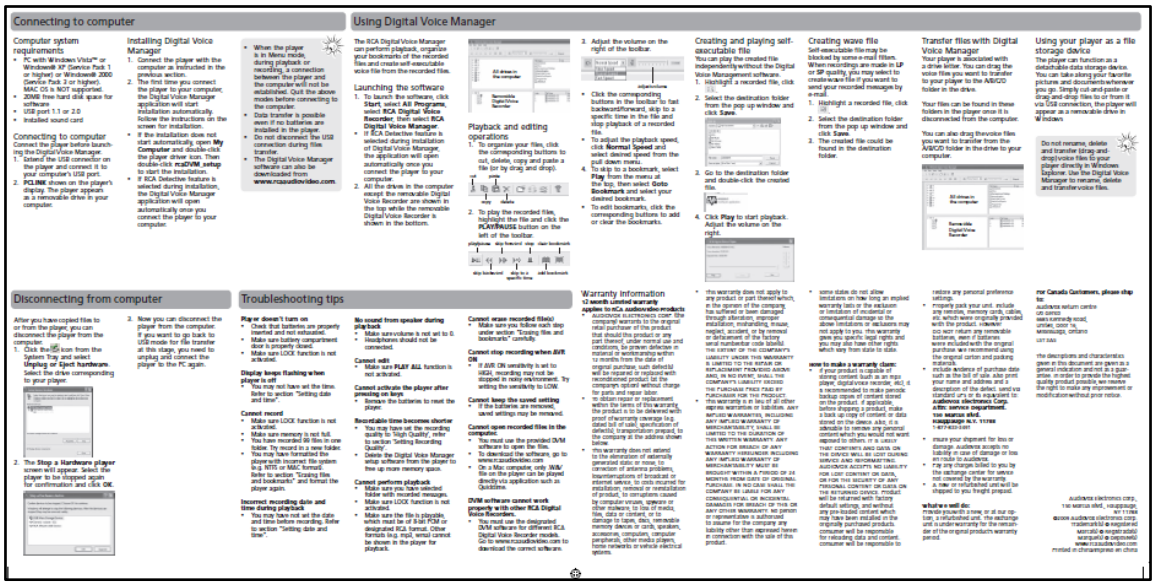



**Figure 123c**. RCA VR5220 digital audio recorder specifications (3 of 3).

# APPENDIX K

## FOCUS GROUP QUESTIONNAIRE

Focus Group Questions:

1. Did you notice any patterns in your experience of stress? Time (chronological), place, dealing with particular people or situations?

2. What we've experienced in a place before can affect or thoughts and/or physiological reactions when we encounter that place again. Did you notice responses of tension to places that are part of your daily path?

3. Were you continuously conscious of the monitoring process? (i.e. checking your HR, seeing if you had good satellite reception, seeing if the unit was still on, etc.)

4. Did you check your heart rate when you felt stressed?

5. Did you become more aware of stress in your life based on having to report in the audio diary and being tracked?

6. Was it easy to follow the protocols? Or did you have trouble remembering to do your sessions, report stress (including constraints, cause, exercise, etc.)

7. Was it easy to use the equipment? Or did you have technical difficulties?

8. Did the monitoring interfere with your daily life in any way?

9. Do you think that you could benefit from stress management training?

10. Did participating in this research change your mind regarding the primary sources of stress in your life? (constraints – authority, biological, coupling; places or environments, etc.)

# VITA

Name: Nikki Anne Williams

Address: 2001 Delvin Lane
Austin, TX 78728

Email Address: nikki.anne.williams@gmail.com

Education History:

Ph.D., Geography, Texas A&M University, August 2012
M.S., Geography, Texas State University-San Marcos, December 2005
B.S., Geography, Texas State University-San Marcos, May 2003